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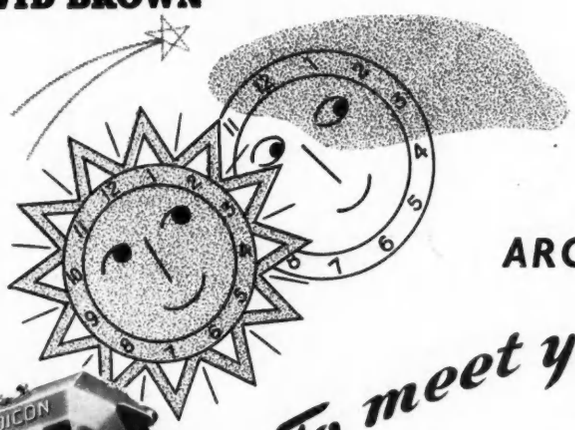

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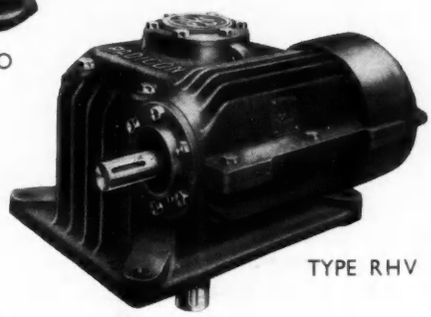

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THE ENGINEER

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LIBERALISING EDUCATION

The Ministry of Education has recently circularised Local Education Authorities on the subject of "Liberal Education in Technical Colleges." It is therefore improbable that there is anything accidental about the coincidence that at a conference between industry and the technical colleges, organised by the Federation of British Industries a week or two ago, there was a paper on "Liberal Technical Education"; and that a month ago the annual May Lecture before the Institute of Metals had as its subject "Technological Humanism." But there is an unfortunate and indeed paradoxical aspect of the coincidence. The least important of these documents is the one most likely to be widely read! The circular to local education authorities is dry and platitudinous and many a principal of a technical college will dismiss its suggestions as impracticable anyway. But in duty bound local education officers and principals and many in more junior positions will no doubt have at least to skim through it. The paper read before the F.B.I. Conference by Dr. Venables, Principal of Birmingham College of Technology, is a much more lively document, much more readable, says much the same things and succeeds in presenting its ideas in such a way that no principal could possibly dismiss them outright as impracticable. But will it be as widely read? As for the May Lecture by Sir Eric Ashby, President and Vice-Chancellor, Queen's University, Belfast, it is really admirable and thought provoking in its suggestion that, properly treated, an education for technology could be and should be as liberal as any other and a good deal more liberal than some. Yet, after exhilarating all who heard it delivered, it will, we fear, now become buried in an institute journal in which those concerned with engineering education are unlikely to look for it. From that fate we endeavour to rescue it by printing excerpts in this issue.

There is, of course, nothing new in the criticism that technological education, at least in this country, has a narrowing influence on the minds of those experiencing it. This journal has been very far from alone, these last forty years and more, in voicing the criticism. Why, then, is it that it is only since the war that a more active interest has been shown by universities and colleges in widening the curriculum? Very probably the reason formerly advanced that room could not be found in an already overcrowded curriculum for subjects not strictly technical was never really valid. For it is to be observed that in German colleges and even in certain colleges in the U.S.A. room was found from the very beginning for such studies. What has been lacking and what critics failed constructively to suggest as the truth, has been an appreciation that a deep study of any technological specialisation can be made to lead on very naturally to a study of wider and more human interests. For the development of every technology necessarily has an impact on human minds and human affairs. It is obvious that the building of a road through an African jungle must alter the human relationships of all the tribes through whose territories it passes. It is only a little less obvious that any technological development in a much more fully developed country must have an influence on its social order. To-day many an engineer whose narrowly technological education has been excellent is confounded to find that proposals which seem to him unanswerably reasonable look quite different to other people. They argue from quite different but just as reasonable assumptions, which take better into account human reactions to a technological proposal. But with relatively little time devoted to subjects that are not strictly technical the minds of students could be awakened to the broad influence of their specialist studies upon life as a whole. It is but a small step, for instance, to go from a technical study of the principles of railway layout to a consideration as to why a railway is being laid out at all. Thence the prospect widens to consider the influence of railways upon the development of industries, upon social contacts, upon economics, upon the movement of populations, upon the widening of political horizons, and the breaking down of parochialism and local customs, and so on. No one would suggest that all of this should be taught. The need is to awaken the student to the fact that it is all there for him excitedly to study should he so desire; that whatever his specialisation similar broad horizons exist, and that he cannot be fully successful as a technologist without taking account of them.

We hope and believe that universities and technical colleges will find a means of introducing more liberal studies into their curricula, studies related to technologies and stimulating the mind to see the wider implications. Specialisation there must

be and indeed the discipline of studying one subject really deeply seems necessary for the production of a lively critical mind. But a glimpse of wider horizons should not be denied to students ; all the more particularly nowadays when so large a proportion of them come from homes with a narrow outlook. Such a change holds out an exciting prospect. Society has not yet adapted itself to the changes that advances in technology have brought about. Little more than fifty years ago the educational system of this country was still suited to a state of affairs in which the populace as a whole was more or less illiterate and the aristocracy and gentry directed and controlled their labours. For that paternal economy concentration upon the arts and the humanities was admirably suited to the education of the literate. Will it happen in the future of our present economy, now so closely geared to the technologies, that the mastery of at least one technology—together with some width of study about it—will be regarded as an essential of a liberal education ? It could be. For it is already coming to be recognised that an education restricted to the arts alone or even to science alone is just as narrowing as one restricted to technicalities. But adequately to play a part in technological advances requires an understanding of art, science and human relations, all three.

COAL IN THE U.S.S.R. AND IN BRITAIN

Since the days of the Pharaohs until comparatively recently mining has been looked upon as one of the most degrading forms of human labour. In olden days miners were either barbarian prisoners of war or persons, male or female, who were *persona non grata* with the ruling power. No freeman ever worked voluntarily in the mines. The conditions underground were appalling and the expectation of life short. During the present century the mines of Laurium from which Themistocles obtained the silver to build the fleet which defeated the Persians at Salamis have been uncovered by open-cast working, revealing a rabbit warren of tiny tunnels in which it would be almost impossible for a normal-sized man to turn round. The heat, cramped conditions and lack of ventilation must have been terrible. To be condemned to the mines was one of the worst punishments that could be inflicted upon a man. It was a lingering death. Yet mining, with agriculture, is one of the two fundamental industries of the world, one regenerative, the other wasting, which enter into every phase of human life. Transport, cooking, industry and even golf levy their basic requirements on the miner's skill at extracting raw material from the earth. During the first half of the last century to 1840 men (and sometimes women) were bonded to the coal mines in Britain for at least one year, while, in Russia, even more recently, mines, especially in Siberia, were manned by political undesirables. Even in 1946 in the Near East there was one coal mine largely manned by men serving a sentence of imprisonment for murder. One year in the mines counted for two of the sentence. Admittedly, the men were not kept in very close confinement. It is interesting to consider these earlier conditions against those of to-day, and wonder whether the pendulum has not swung too far and too fast in the other direction.

In Britain the annual production of coal is now below requirements and has to be supplemented at a high cost from overseas. Consequently, the miner is able to put heavy pressure upon the producers, the National Coal Board. The result is a regular demand for a wages increase without any corresponding increase of effort. Yet many miners, more so, perhaps, than other workmen, appear to have a wages " ceiling," so that any increase in price rate or daily wages results not in a bigger pay packet but an increase in leisure. The miners to-day are the highest paid of any industrial workmen. But are they the hardest worked or is mining the most dangerous occupation ? By clever propaganda over a long number of years the British public has become convinced that this is so, but would an impartial analysis of hours of work—not time spent underground—show it to be so ? Is it possible that this attitude is a natural revulsion from the conditions of olden days ? These comments do not apply to the individual miner because individually the miner is a fine fellow, both in peace and war, but living as he does in a close community of his fellow tradesmen he is easily led by a militant minority. Compare the Soviet coal mining industry with Britain's. Some facts about it are revealed by a technical mission of the National Coal Board which recently visited Russia and which published its report in March. The U.S.S.R. has ample coal reserves to meet requirements for generations and this coal is found in thick seams near the surface under good natural conditions. Consequently there is no difficulty in mining it, and once transport has become adequate there should be no difficulty in supplying Russian industry with all its requirements. As in Britain, the Soviet miner is the highest paid industrial worker in his country. Nevertheless, the fear of being sent to the mines still lingers and serious steps are being taken to obliterate it. One of the more important is education, not only of the miner but of mechanics, electricians and their overseers who are employed in mining communities. It used to be common, and maybe still is, to see in backward countries the latest Western machinery deteriorating rapidly for want of elementary care and maintenance. The Soviets recognise this but have a long way to go before it is counteracted. Lack of housing and lack of transport facilities hold down development and attention is being paid to these. Amenities as known among Western mining communities are scarce. If the Soviet Government read history, which is not " bunk " and so develop their mines and improve the general living conditions, they may in time obliterate the memory of the past and then coal from Russia may dominate the Mediterranean and Western European countries. The coal is there, the labour is there, which may result in an excess production over internal demands. Will Britain then become dependent upon Russian coal for industrial existence ?

According to the recently issued report, underground mechanisation is going ahead in Russia, generally following western lines, e.g. electrically-driven chain coal cutters, chain, as opposed to belt, face conveyors and heading machines. The Soviet machines differ little in design from the conventional Western machines but seem, possibly owing to better natural conditions, to be both larger and heavier. Diesel locomotives or canvas-rubber belt conveyors are not much used at present but their great advantages will be recognised in time and installed underground. One of the great problems in Britain to-day is roof support : the earlier working of seams lying above or below those at present being worked has fractured the intermediate ground, rendering it difficult to support, especially in longwall machine-mined faces where a clear, unhindered run for the coal cutter is essential to success. The use of rigid and sliding steel supports, dry stone walls and even complete filling by hand or more usually mechanised including pneumatic or hydraulic means, cannot prevent falls of roof near the working face and particularly subsidence of the ground at the surface, with its resultant damage to buildings and public services, water, gas and sewerage. The Russians do not appear to have been faced with this problem yet, working, as they are, the primary seams of their coalfields. There do not appear to be available any figures to show whether the input of expensive machinery into the Russian mines has improved the output per man employed or merely eased his labour. In Britain the output per man-shift is slowly going up but in view of the hundreds of millions of pounds sterling that have been spent on and in the mines since nationalisation, it is a question as to whether value for money is being obtained by the nation. In good times men may be inclined to leave the mines for cleaner work in say, a motor-car factory, and it may be that part of the expenditure is necessary as an insurance to keep the existing labour from being attracted away.

A Seven Day Journal

Silting in the Thames Estuary

AN account of the painstaking research studies which have been carried out to investigate the behaviour of the Thames estuary, and in particular silting, were described last week at the Institution of Civil Engineers, when the paper, " The Regimen of the Thames Estuary as Affected by Currents, Salinities and River Flow," by Sir Claude Inglis and Mr. F. H. Allen, was presented for discussion. The work has included measurements from a survey launch and model studies with the large-scale tidal model which we described in this journal on February 1, 1952. Radioactive tracers were also used to study the movement of mud. The regime concept was applied to this study, the main variables governing conditions in the estuary being (i) tidal oscillations, (ii) upland fresh water flow, and (iii) the supply of solids carried into the estuary in suspension or as bed loads from either the tidal or fresh water flows.

The results of the study indicated the importance of density currents, which are part of the natural mechanism for maintaining salt and fresh water balance, as agents for transporting silt upriver near the bed to zones of recent dredging. Thus one of the principal findings was that dredgings dumped near the estuary's seaward limit tend to return to the areas from which they were originally dredged. The authors point out that dredged material should therefore be pumped ashore. " This will have no immediate effect on the estuary," it is stated, " because regime is a delicate balance between accretion and erosion. Gradually, however, the balance will change until eventually a considerable improvement will occur, with a corresponding reduction in the amount of dredging required." At the meeting, Lord Waverley announced that this recommendation was to be followed, and the P.L.A.'s first site for dumping silt of 240 acres at Rainham, Essex, was expected to be adequate for about 7½ years. The L.C.C., which dumps sewage sludge at Black Deep, was also being asked to co-operate, he added.

Main Line Diesel-Electric Locomotive for British Railways

THE first locomotive to be completed under the modernisation plan for British Railways was handed over to Lord Rusholme, member of the British Transport Commission, at Vulcan Foundry, Newton-le-Willows, on Monday last, by Sir George H. Nelson, chairman of the English Electric Company, Ltd., and the Vulcan Foundry, Ltd., the builders of the locomotive. This 1000 h.p. main line diesel-electric locomotive is of the type " A " announced by the British Transport Commission when it placed its first major contracts for the modernisation programme in November, 1955. The locomotive is the first of twenty type " A," ten type " B " and ten type " C " to be built by the English Electric group, and is intended for mixed traffic working, being equally suitable for passenger or freight duty. The design is such that the locomotives can be coupled together in multiple units either with similar locomotives or with those of types " B " or " C." With a B_0-B_0 wheel arrangement the locomotives weigh 72 tons in working order and are designed for a maximum speed of 75 m.p.h.; the maximum tractive effort being 42,000 lb and the continuous rated tractive effort 19,500 lb.

During the ceremony of handing over of the locomotive, Lord Rusholme said that this year British Railways expected to take delivery of nearly fifty main line diesel units, but by 1960 orders should have reached a much higher level. Over 600 diesel shunting locomotives, or power equipments for such units, had been ordered this year alone. More than 600 vehicles for multiple-unit diesel trains had already been delivered and very substantial orders had been placed for many hundreds more.

The Engineer
100 Years Ago

(JUNE 5, 1857)

" THE KENSINGTON MUSEUM "

" It is at present intended to open the new museum at South Kensington on the 15th inst., although the day is not definitively fixed. Our readers are aware that one very important feature in the Government scheme is the formation of a patent museum, to contain models of the most important inventions and specimens of new products and manufactures. It is further intended, at some future time, to form a duplicate library to the one in the building in Chancery-lane, and also to form a gallery of portraits of eminent men who have shared in swelling the patent lists. Thus under the term Patent Museum are really included three most important undertakings —the collection of models, the library, and the portrait gallery, each of them of considerable interest in itself, but when placed under one roof and capable of being studied simultaneously, more interesting still. . . .

" We are not particularly disposed to find fault, although we could point to some important defects in the general arrangement of the Museum building, such as separating the various parts of it by partitions carried up to the roof instead of making a light and low railing mark the divisions, which would have answered every purpose, and not obstructed the *tout ensemble*. What harm would it have done if, at the end of a long row of architectural ornaments, for instance, a statue had been seen in the distance ; or would it have marred the effect of a row of educational models if at the end had been seen one of those in the Patent Museum ? We think not ; indeed we believe the pleasing effect of each department would have been immeasurably increased by the entire building being seen at one view. As it is, however, we accept it as a propitious start, being satisfied to take the building and its contents as they are. We have no hesitation in saying that visitors to Kensington will find there not only much to admire, but also to amuse and instruct them."

Steel Castings Research

THE new laboratories, recently completed by the British Steel Castings Research Association at East Bank Road, Sheffield, were opened last Tuesday by Sir Harry Jephcott, chairman of the Council for Scientific and Industrial Research. Speaking at a luncheon prior to the ceremony, Sir Harry expressed the hope that the Association would continue its close connection with Sheffield University and other universities with which it had placed " research contracts." He commended especially the value of supporting research studentships in universities.

Scientific manpower, Sir Harry continued, was still a scarce commodity. The demand for the services of university graduates was such that it was essential for them to realise that the steel founding industry was one which could offer worthy opportunities to the scientist and technologist. Sir Harry also referred to one of the Association's declared aims, namely, " to encourage and improve the education of persons engaged or likely to be engaged in the steel castings industry." That, he said, was one way of ensuring the rapid application of research results ; he hoped that the Association would maintain a close connection with the technical college, and that the two organisations would be able to be of mutual help to the benefit of the industry.

British Computer Society

PARTICULARS concerning the formation of a new body to be called the British Computer Society have been given in a statement issued this week. In view of the increasing use of computers and automatic data-handling techniques, a working party was formed some months ago to examine a proposal to form a national society, where information could be exchanged between people concerned with the scientific, engineering and business aspects of computers. The objects of the new society are, to provide an organisation for those interested in, and to further the development and use of, computational machinery and the techniques allied thereto ; to facilitate the exchange of information and views and to foster well-informed public opinion on this subject ; to hold conferences and meetings for the reading of papers and delivery of lectures, and to publish a journal and other information for the benefit of its members.

The London Computer Group, which was formed in 1956, has agreed to take part in the formation of the new society and to add its resources to it. Existing members of the group will automatically become members of the new society. A provisional council has already been appointed, and it is the intention of the society to form regional and specialist groups. At the outset a business group and an engineering and scientific group will be set up.

Birmingham Factory Extension

ON Thursday last week, the new offices of the Phosphor Bronze Company, Ltd., Bradford Street, Birmingham, were opened by the Bishop of Aston, the Right Rev. C. G. St. M. Parker. The extension of the factory which has taken place involved building over the River Rea. The offices are in a five-storey block : since the firm is essentially a jobbing foundry, a particularly effective administration is involved in dealing with about 12,000 separate customers. Accounting and costing information is stored entirely on punched cards, and all ledger and payroll preparation is mechanised.

Birfield Industries, Ltd., to which group the company belongs, has established a residential centre for industrial education at Stratford-on-Avon. This is located at Goldicote House, the present building being a nineteenth century residence with a recently added wing, but the records of the site under the same name extend back to its use as a deer park in 972. The activities there consist of conferences, not lectures, and are part of the work of all directors, managers, foremen, and apprentices in the group.

Improved Methods of Particle Size Analysis

By T. H. HUGHES

Air elutriation is the process of "size-grading" the particles of a sample of dust in an upward stream of air. Separation of the dust into two selected size fractions occurs when the velocity of the air stream corresponds to the terminal velocity of the particles of the selected size. Particles smaller than this size are carried upwards and out of the system whilst particles which are larger are retained. By using a range of velocities, the size distribution of a dust may be determined. By adopting new methods of dispersal, it has been found possible to elutriate the sticky kinds of dust which would not respond to the standard method of elutriation. It has also been possible to reduce the time of elutriation for free flowing kinds of dust. The work described in this article showed that a reduction in the time for elutriation was obtained when special measures were adopted to disperse the dust either in a completely standard apparatus or when using a special attachment for this purpose. Tests were also carried out to show the effect of individual factors which contribute to improved rates of elutriation. The apparatus used was basically an air elutriator of the Gonell type,[1] which was constructed according to the British Standard Specification 893,[2] 1940.

WHEN size grading a dust by air elutriation difficulty often arises in dispersing the dust as discrete particles in the air stream, particularly when making "cuts" at say 5 microns, where the velocity of the air stream may be of the order of only 0·15cm per second. At these low velocities some of the sticky dusts are troublesome since they tend to form aggregates during the process.

This fact will be readily appreciated from Fig. 1, which shows the condition assumed by a "sticky" dust in the base of a standard type of air elutriator during elutriation at 5 microns.

Description of Apparatus and Methods of Tests

Standard Method.—The standard apparatus is shown diagrammatically in Fig. 2. Its construction and the method of test are fully described in the British Standard. However, the procedure of elutriation may be summarised as follows. The sample of dust to be examined is placed in a conical container at the base of the largest of the three columns of the elutriator and the required amount of air is passed through it. The flow of air causes the sample of dust to behave as a "fluid bed" from which the particles of dust are gradually released and carried upwards into the main portion of the column, where size classification takes place. At the conclusion of the elutriating period, the air supply is turned off and a period of time, as given in Table I, is allowed for the particles suspended in the elutriating column to settle into the dust container at the base. The dust in the container is then weighed. The process is repeated using periods of time according to Table I until the loss of weight of the dust remaining in the container is not more than 1 per cent in any given cycle. At this stage of the test the "end-point" is considered to have been reached for that particular "cut." In order to complete the size analysis of the sample, the cone containing the remaining dust is transferred to the next smaller tube and finally to the smallest tube, elutriation being carried out in each case according to the times given in Table I until "end-point" has been reached.

The diameters of the three tubes are 5·5in, 2·75in and 1·375in respectively. The same air flow can therefore be used to "cut" at say 10 microns in the largest tube, 20 microns in the intermediate and 40 microns in the smallest tube. To "cut" at 5 microns the velocity in the largest tube must be reduced to one quarter of that used for 10 microns.

Modified Method of Using the Standard Apparatus

With a modified method, which requires no additional apparatus, dispersal of the sample for cuts at 5 microns is appreciably improved by passing about twenty times the normal flow of air into the column for a short time at the commencement of each cycle of elutriation. For cuts at 10 microns and above only about 5 times the normal air flow is required. The additional flow of air during this initial period increases the agitation of the bed of dust, and tends to prevent the formation of aggregates. It also increases the rate at which the sample is entrained in the air stream and eventually dispersed in the main portion of the column.

Knowing the velocity of the air in the column during the initial period, the flow may be adjusted to the required rate for making the "cut" just before the first particles reach the top of the column. After this the normal procedure is followed. The duration of the initial period of dispersal for the various "cuts" is given in Table I.

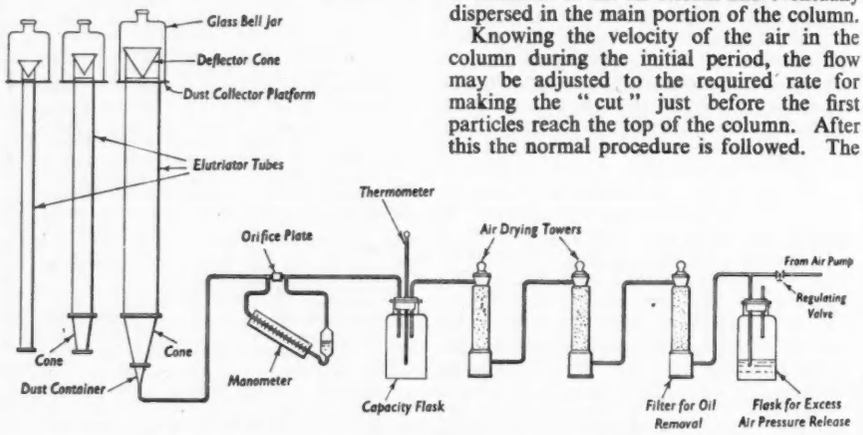


Fig. 2—General arrangement of apparatus for air elutriation

Fig. 1—Aggregates produced in the dust container with the standard conditions of elutriation

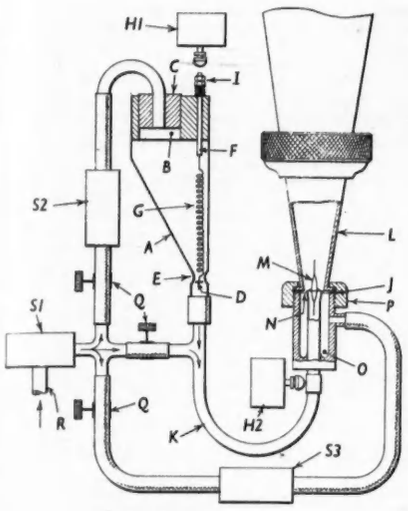
Special Apparatus for Dispersing the Dust

Although the modified method of operation considerably improves the performance of the standard apparatus at low velocities, it was considered possible to obtain still better dispersal of the dust by replacing

Table I—*Cycles of Elutriation*

Method of elutriation	† "cut" microns	Elutriating periods: Initial dispersal of the dust, seconds	Elutriating periods: Elutriation, First, minutes	Elutriating periods: Elutriation, Subsequent, minutes	Settling times, min. sec.
Standard	5	—	60	30	13 40
	10	—	60	30	3 25
	20	—	45	20	0 44
	40	—	30	15	0 10
Modified method using the standard apparatus	5	35	60	30	13 40
	10	35	60	30	3 25
	20	8	45	20	0 44
	40	2	30	15	0 10
Modified method using a special apparatus for initially dispersing the dust in the air stream	5	35	15	15	13 40
	10	35	*5	5	3 25
	20	8	4	4	0 44
	40	2	2	2	0 10

* When the initial cut is at 10 microns this period is 10 minutes.
† Based on the particles having a specific gravity of 2·2.



A—Feed hopper.
B—Filling hole.
C—Plug.
D—Feed control disc.
E—Throat.
F—Plunger.
G—Helical spring.
H1-2—Rapping device.
I—Feed adjusting nuts.
J—Sealing ring.
K—U-tube.
L—Cone.
M—Glass diffuser.
N—Annulus for oversize particles.
O—Oversize collecting hopper.
P—Clamping nut.
Q—Adjusting clips.
R—Air supply.
Air Flow Indicators
S1—Total.
S2—To feed hopper.
S3—To annulus for oversize particles.

Fig. 3—Diagrammatic arrangement of the dispersing apparatus

the conical dust container at the base of the standard apparatus with a special arrangement which would perform two functions :

(*a*) Feed all the dust into the air-line in a gradual stream during the initial period when the air is entering the column at a high rate of flow.

(*b*) Prevent the accumulation and re-cycling of oversize particles in the air stream at the base of the column, thus allowing the whole dust sample to enter the elutriating column in a dispersed state without first passing through a bed of recirculated oversize dust.

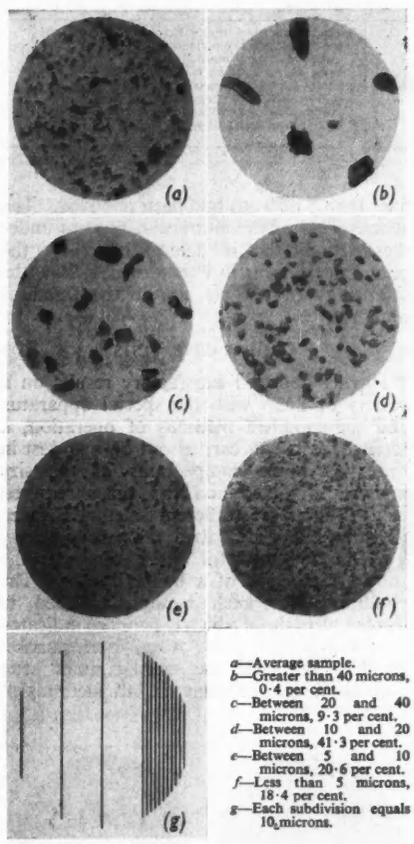
The apparatus which was developed to do this is shown diagrammatically in Fig. 3.

Description of the Apparatus.—As will be seen from Fig. 3, the sample is introduced into the feed hopper *A* through the filling hole *B* by removing the plug *C*. The dust is supported at the base of the hopper by a sharp edged disc *D* situated below the throat *E* and suspended from the plunger *F* by a helical spring *G*. A vibration which is imparted to the plunger *F* by the rapping device H_1 causes the disc *D* to oscillate vertically and thereby to vary the width of the annulus between the edge of the disc *D* and the surrounding throat *E*. At the same time the dust immediately above the disc *D* is agitated by the pulsation of the spring *G* and is assisted to flow through the annulus by a small proportion of the main air supply which enters the hopper through the filling hole *B*. The feed rate is controlled, either by varying the width of the annulus, adjustment being made by two locknuts *I* which raise or lower the oscillating position of the disc relative to the throat, or, alternatively, by altering the proportion of the air passing through the feed hopper.

The dust from the feeder is entrained in the air stream at a point where the main air supply *R* enters the U-tube *K* and is swept into the cone *L*, which connects the apparatus to the main column of the elutriator. A glass diffuser *M* is situated at the exit of the U-tube *K* to improve the velocity distribution at the base of the cone. The difference in diameter of the exit of the U-tube *K* and the apex of the cone *L* forms an annulus *N* through which pass the oversize particles. These particles eventually collect in the hopper *O*. In order to recirculate any fine particles which settle with the oversize, a small quantity of air, by-passing the U-tube *K*, rejoins the main stream in the column via the hopper *O* and the annulus *N*. Fig. 4 shows the apparatus fitted to the largest column of the elutriator.

Method of Operation.—The air flow and the dust feeder controls are set to predetermined positions according to the nature of the dust. That is, the air controls are set to give the required proportions through the feed hopper, and the annulus for oversize particles, during the initial period of increased air velocity, and the dust feed rate is set so that the whole sample enters the column within the initial period. The setting of the rate of dust feed is determined experimentally before the test commences, particularly if the dust tends to be either abnormally sticky or free flowing. When the sample of dust has been placed in the feed hopper, the air supply and the vibrators are switched on simultaneously and no further adjustment is made until the end of the initial period. The main air control is then adjusted to give the total air-flow rate for the required size grading of the particles, and this is maintained for periods of fifteen minutes for cuts at 5 microns, five minutes at 10 microns, four minutes at 20 microns and two minutes at 40 microns respectively, as shown in Table I.

Table I shows that the above times are considerably shorter than those used with the standard apparatus. This has been possible with the special apparatus because, after a short interval of time, which may vary slightly with the type of dust, the particles will be either dispersed in the main column, where elutriation is taking place, or deposited in the hopper as oversize. Therefore, the time required need only be sufficient for the particles entrained in the air stream to be carried out of the elutriating column. The times given for the special apparatus in Table I are those which experience has indicated to be most suitable to deal with the range of dusts which have been examined.



a—Average sample.
b—Greater than 40 microns, 0·4 per cent.
c—Between 20 and 40 microns, 9·3 per cent.
d—Between 10 and 20 microns, 41·3 per cent.
e—Between 5 and 10 microns, 20·6 per cent.
f—Less than 5 microns, 18·4 per cent.
g—Each subdivision equals 10 microns.

Fig. 5—Size fractions of a sticky dust of uniform density

After the requisite time has been allowed for settling, the dust is recovered from the apparatus and weighed. The process is then repeated until the normal " end-point " of not more than 1 per cent loss of weight is reached on each of the three columns.

The Use of the Apparatus for Elutriating Sticky Dusts.—It has already been pointed out that certain kind of very fine dust are inherently sticky and tend to form aggregates when agitated in an airstream of low velocity. These dusts are extremely difficult, and in some cases impossible, to elutriate in the standard apparatus, as indicated by Fig. 1, even when an initial period of high velocity is used at the commencement of each elutriating period. When using the special apparatus for dispersing the dust instead of the standard container, the formation of aggregates almost ceased after the second cycle of elutriation. Subsequent microscopic examination of the oversize showed that it was practically free from superfine particles. Elutriation of the dust at 10 microns and above was possible with the standard apparatus after the fraction

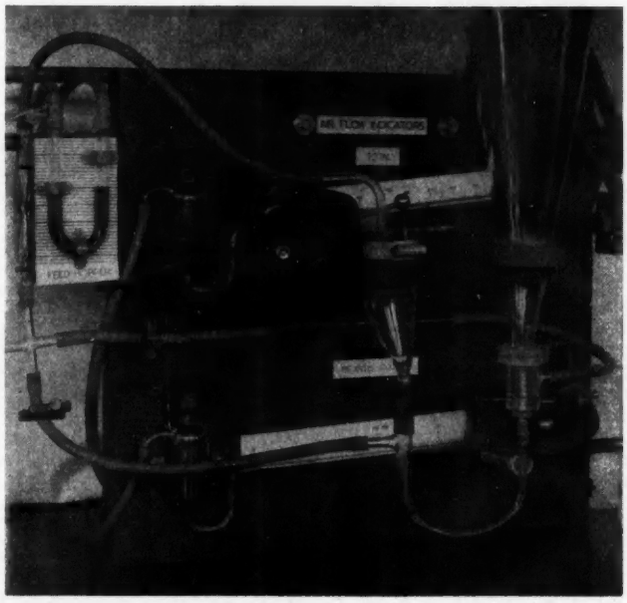


Fig. 4—Dispersing apparatus fitted to the largest tube of the standard elutriator

TABLE II—*Test Results—Comparison of Standard and Modified Procedures*

Test No.	Conditions	Equivalent particle size at which the dust is separated, "D"															
		"D"=5 microns				"D"=10 microns				"D"=20 microns				"D"=40 microns			
		Duration of elutriating periods, min	No. of elutriating periods	Total time of "cut," h min	Weight smaller than "D," per cent	Duration of elutriating periods, min	No. of elutriating periods	Total time of "cut," h min	Weight smaller than "D," per cent	Duration of elutriating periods, min	No. of elutriating periods	Total time of "cut," h min	Weight smaller than "D," per cent	Duration of elutriating periods, min	No. of elutriating periods	Total time of "cut," h min	Weight smaller than "D," per cent
1	Standard apparatus	60*	8	4 30	10·6	60*	10	5 30	76·1	45*	4	1 45	95·5	30*	2	0 45	99·4
	Standard test procedure	30†	—	—	—	30†	—	—	—	20†	—	—	—	15†	—	—	—
1a	Standard apparatus	—	—	—	—	60*	10	5 30	76·7	45*	5	2 5	95·7	30*	2	0 45	99·5
	Standard test procedure	—	—	—	—	30†	—	—	—	20†	—	—	—	15†	—	—	—
2	Standard apparatus	60*	13	7 0	50·9	60*	5	3 0	78·2	45*	4	1 45	96·2	30*	2	0 45	99·4
	Standard periods of elutriation; initial dispersal of dust assisted by using an increased air velocity	30†	—	—	—	30†	—	—	—	20†	—	—	—	15†	—	—	—
2a	Standard apparatus	—	—	—	—	60*	7	4 0	77·0	45*	5	2 5	95·7	30*	2	0 45	99·4
	Standard periods of elutriation; initial dispersal of dust assisted by using an increased air velocity	—	—	—	—	30†	—	—	—	20†	—	—	—	15†	—	—	—
3	Special dispersing apparatus; shorter periods of elutriation; initial dispersal assisted by using an increased air velocity	15	8	2 0	52·0	5	7	0 35	79·5	4	5	0 20	96·2	2	2	0 4	99·2
3a	Special dispersing apparatus; shorter periods of elutriation; initial dispersal assisted by using an increased air velocity	—	—	—	—	10*	11	1 0	78·2	4	4	0 16	95·7	2	2	0 4	99·3
		—	—	—	—	5†	—	—	—	—	—	—	—	—	—	—	—

* First cycle of elutriation. † Subsequent cycles of elutriation.

finer than 5 microns had been removed. The effectiveness of the elutriation process under these conditions is demonstrated by the photomicrographs in Fig. 5, which show the uniformity of particle size in the fractions obtained.

COMPARATIVE TESTS

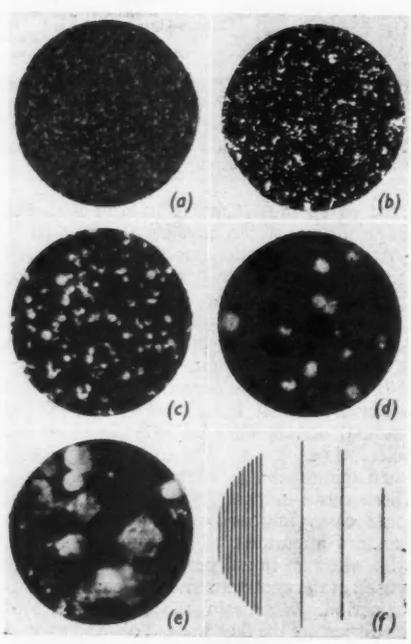
Having obtained satisfactory results on a variety of dusts with the special apparatus and the modified methods of operation, a series of tests was carried out on one dust in order to make comparisons of the size analyses obtained and the times required using the three different methods given in Table I and described more fully below. The dust selected for these tests was the sub-sieve fraction of a boiler fly ash. The conditions for each method outlined in Table I were those which experience indicated would give the best overall performance. Incidentally, since the settling times after elutriation are the same for all methods of test, they are not included in subsequent tables showing the performance of the apparatus. The tests were carried out on samples of the dust at 5, 10, 20 and 40 microns by each of the three methods. Test 1 was carried out by the standard method, test 2 by the standard method modified to include an initial period during which the sample was dispersed in the elutriating column by using air at a high velocity, and test 3 using the same modification in method in conjunction with the special apparatus for dispersing the dust in the air-stream before it enters the elutriating column.

In order to determine whether breakage of the particles occurred as a result of the increased agitation to which they were subjected with the modified methods during the process of dispersal, repeat tests 1*a*, 2*a* and 3*a* were carried out by each of the three methods commencing the elutriation at 10 microns instead of 5. It seems reasonable to assume that if breakage of the particles occurred during the cut at 5 microns, it would be reflected in the size distribution of the fractions larger than 5 microns.

TEST RESULTS

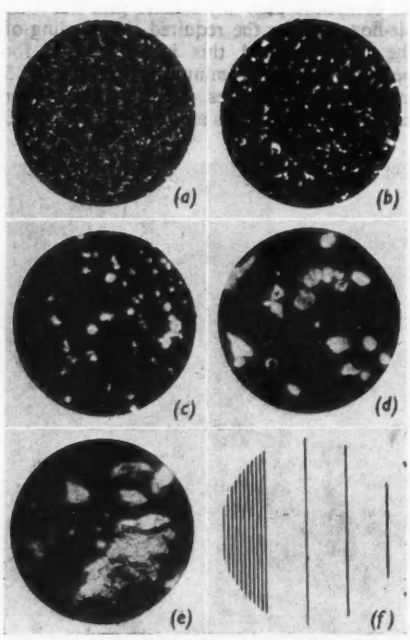
The overall results of the tests are given in Table II.

Accuracy of "Cuts."—On comparing the cumulative weights of undersize obtained in tests 1, 2 and 3, Table II, it will be seen that when "cutting" at 20 and 40 microns there is no appreciable difference in the percentage of undersize obtained by the three methods, but in the smaller sizes there is a progressive increase in the percentage of undersize as the method of dispersing the dust improves, the difference being greatest in the smaller size range. For example, at 10 microns the undersize is increased from 76·1 to 78·2 per cent when the dust is dispersed with high velocity air in the standard apparatus and it increases still further to 79·5 per cent when the special apparatus



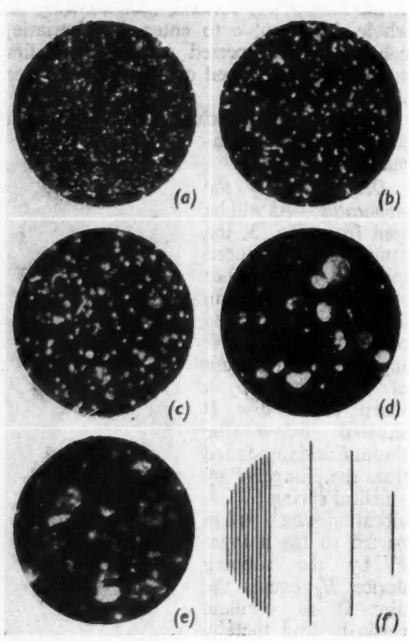
a—Stokes diameter, less than 5 microns.
b—Stokes diameter, between 5 and 10 microns.
c—Stokes diameter, between 10 and 20 microns.
d—Stokes diameter, between 20 and 40 microns.
e—Stokes diameter, between 40 and 66 microns.
f—Each subdivision equals 10 microns.

Fig. 6—Size fractions of fly-ash obtained by the standard method of air elutriation



a—Stokes diameter, less than 5 microns.
b—Stokes diameter, between 5 and 10 microns.
c—Stokes diameter, between 10 and 20 microns.
d—Stokes diameter, between 20 and 40 microns.
e—Stokes diameter, between 40 and 66 microns.
f—Each subdivision equals 10 microns.

Fig. 7—Size fractions of fly-ash obtained with the standard apparatus using a high initial air velocity



a—Stokes diameter, less than 5 microns.
b—Stokes diameter, between 5 and 10 microns.
c—Stokes diameter, between 10 and 20 microns.
d—Stokes diameter, between 20 and 40 microns.
e—Stokes diameter, between 40 and 66 microns.
f—Each subdivision equals 10 microns.

Fig. 8—Size fractions of fly-ash with special dispersing apparatus using high initial air velocity

TABLE III—*Test Results—Effect of Individual Modifications*

Test No.	Conditions	Equivalent particle size at which the dust is separated, "D"															
		"D"=5 microns				"D"=10 microns				"D"=20 microns				"D"=40 microns			
		Duration of elutriating periods, min	No. of elutriating periods	Total time of "cut," h min	Weight smaller than "D," per cent	Duration of elutriating periods, min	No. of elutriating periods	Total time of "cut," h min	Weight smaller than "D," per cent	Duration of elutriating periods, min	No. of elutriating periods	Total time of "cut," h min	Weight smaller than "D," per cent	Duration of elutriating periods, min	No. of elutriating periods	Total time of "cut," h min	Weight smaller than "D," per cent
1*a*	Standard apparatus	—	—	—	—	60*	10	5 30	76·1	45*	4	1·45	95·5	30*	2	0 45	99·4
	Standard test procedure	—	—	—	—	30†	—	—	—	20†	—	—	—	15†	—	—	—
4	Standard apparatus	—	—	—	—	10*	—	—	—	—	—	—	—	—	—	—	—
	Shorter periods of elutriation ...	—	—	—	—	5†	9	0 50	58·8	4	5	0 20	92·9	2	2	0 4	99·5
2	Standard apparatus	60*	13	7 0	50·9	60*	5	3 0	78·2	45*	4	1 45	96·2	30*	2	0 45	99·4
	Standard periods of elutriation; initial dispersal of dust assisted by using an increased air velocity	30†	—	—	—	30†	—	—	—	20†	—	—	—	15†	—	—	—
5	Standard apparatus; shorter periods of elutriation; initial dispersal of dust assisted by using an increased air velocity	15	13	3 15	42·0	5	7	0 35	76·1	4	4	0 16	94·9	2	2	0 4	99·6
3	Special dispersing apparatus; shorter periods of elutriation; initial dispersal of dust assisted by using an increased air velocity	15	8	2 0	52·0	5	7	0 35	79·5	4	5	0 20	96·2	2	2	0 4	99·2
6	Standard apparatus combined with dust feeder; shorter periods of elutriation; initial dispersal of dust assisted by using an increased air velocity	15	13	3 15	48·8	5	8	0 40	76·9	4	5	0 20	96·0	2	2	0 4	99·4

* First cycle of elutriation. † Subsequent cycles of elutriation.

for dispersing the dust is used. At 5 microns the difference in the amount of undersize is far greater, increasing from 10·6 to 50·9 per cent when the dust is dispersed at a high velocity in the standard apparatus and to 52 per cent when the special apparatus is used.

These apparent differences in the fineness of the dust, could have two possible explanations. On the one hand, a test could indicate that the dust is coarser than it really is because poor dispersal of the particles results in a proportion of the fines being retained with the oversize; it will be shown later that this occurred in test 1. On the other hand, the results could indicate that the dust is finer than it really is because breakage of the particles has occurred as a result of the agitation used for dispersing the dust by the new methods. It will also be shown later that breakdown did not occur to any marked degree in either tests 2 or 3.

The photomicrographs, Figs. 6, 7 and 8, give a general indication of the accuracy of the "cuts." A comparison of the fractions between 5 and 10 microns, shows that when the "cut" at 5 microns is carried out by the standard method (Fig. 6) an appreciable quantity of fines is retained with the oversize. On the other hand, when air at a high velocity is used to disperse the dust, with either the standard apparatus or the special dispersing apparatus (Figs. 7 and 8) the fraction between 5 and 10 microns is relatively free of undersize particles. This suggests that the unmodified standard method is unsuitable for "cuts" at 5 microns, since it will tend to show the dust much coarser than it is. The size fractions above 10 microns which are shown in Figs. 6, 7 and 8, are sensibly the same whichever method is used, and if due allowance is made for variation in the density of the particles which occurs in fly ash, most of the particles appear to lie within the prescribed limits of size.

The results of tests 1*a*, 2*a* and 3*a*, Table II, which commenced with a "cut" at 10 microns, provide a base line to indicate whether breakage of the particles occurred during the period at a high air flow in the tests 2 and 3, which commenced with a "cut" at 5 microns. If breakage did occur in tests 2 and 3, it would be expected to increase the number of particles smaller than 10 microns, as well as those smaller than 5 microns. The differences between the percentages of material less than 10 microns in the tests which commenced at 10 microns (tests 1*a*, 2*a* and 3*a*) and those obtained by the corresponding methods commencing at 5 microns (tests 1, 2 and 3), are small, being only of the order of 1 per cent. Hence, breakdown of the particles is unlikely to account for the big difference in the percentage smaller than 5 microns, and that the increased percentage of undersize obtained by the new methods is the result of more efficient separation of the dust into size fractions, and not to breakdown of the particles.

Rate of Elutriation.—Not only does improved dispersal of the dust in the air stream during the initial stages enable more accurate results to be obtained at the finer size limits, but it also results in the elutriation being completed in a shorter time, as shown in Table II. The curves plotted in Fig. 9 show

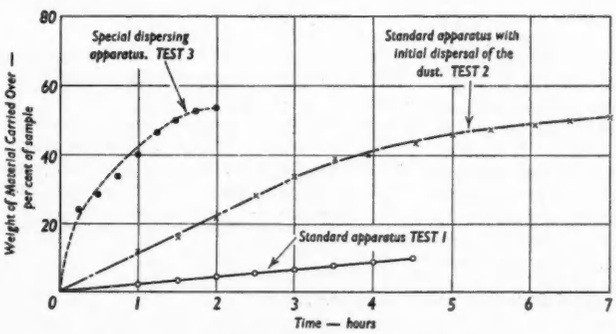


Fig. 9—Rate of elutriation at 5 microns

the rate of elutriating the dust at a cut of 5 microns in tests 1, 2 and 3. With the standard method the "end-point" was reached in four and a half hours, but it has been shown already that even after this long period, separation was far from complete. From the slope of the curve an infinite time of elutriation would seem to be required to obtain a reliable result. When a high velocity was used to disperse the dust at the commencement of each elutriating period in the standard apparatus, a more satisfactory result was obtained, but it required seven hours to complete the test. The curve for the data obtained with the special dust-dispersing apparatus, however, shows that a slightly higher percentage of undersize was obtained in only two hours. The question of the time taken for elutriation will be considered in more detail below.

Effect of Individual Modifications

It will have been realised that the special apparatus used in test 3 for assisting the initial dispersal of the dust in the airstream and the recommended method of operating it, include a number of variations from the standard method of elutriation given in British Standard No. 893 and that each of these variations may have influenced the results obtained. Further, it is conceivable that some of the variations used in test 3 might have been incorporated in the standard apparatus with advantage. For example, a comparison of tests 1 and 2 shows that dispersal of the dust by using a high initial velocity of the air improves the performance of the standard apparatus. This point was taken into account in considering the results of the preliminary tests upon which the recommended apparatus and procedure were based. However, to illustrate their effect, the results of three further tests are given in Table III, in which they are associated with appropriate tests from Table II to facilitate comparisons.

In test 4, the shorter periods of elutriation which were found to be satisfactory when using the special apparatus in test 3, were used with the standard apparatus and their effect will be shown by comparison with test 1*a* in which the same apparatus was used with the standard periods. In test 5 the shorter elutriating periods were used again with the standard apparatus but an initial period of high velocity air flow was used. Test 5 will be compared with test 2 in which the normal elutriating periods were used with an initial period of high velocity air flow. Finally test 6 was carried out to show the effect of using a collecting hopper to remove the oversize at the base of the column; apart from the hopper the apparatus and procedure were as in test 3. Alternatively the apparatus used in test 6 can be regarded as the standard apparatus with the addition of the feeder and with a modified method of operation. From this aspect the results of test 6 are compared with those of test 5.

The Effect of Shorter Periods of Elutriation.—Comparison of tests 1*a* and 4, Table III, shows that similar results were obtained at 40 microns in times of forty-five minutes and

four minutes respectively. At 10 and 20 microns, however, when shorter periods were adopted the percentage of undersize was appreciably less than that obtained by the standard method. Hence, when making cuts at 10 and 20 microns shorter elutriating periods should not be used with the standard apparatus.

Comparing the results of tests 2 and 5 in both of which a high initial velocity of the air stream was used to entrain the dust, but in which the elutriating period was varied, it will be seen that the cumulative percentage of undersize at 10, 20 and 40 microns is of the same order in both cases. It is of interest to note that the times required to complete the "cuts" in test 5 when the shortened elutriating periods were adopted are nearly the same as those required when the special apparatus was used, test 3, indicating that over this size range good results can be obtained by using an improved method of operating the standard apparatus. If however, it is necessary to make a cut at 5 microns the modified method of operation should not be used with the standard spparatus as it will give inaccurate results. Thus, test 5 yielded only 42 per cent of material smaller than 5 microns compared with 50·9 per cent in test 2 and 52 per cent in test 3.

The Effect of Removing the Oversize.—Test 6 was carried out to determine to what extent the improved rates of elutriation obtained with the special dispersing apparatus, were due to immediate removal of the coarse material which would otherwise interfere with the distribution of the dust in the air stream.

A comparison of the results of tests 3 and 6, Table III, shows that without the collecting hopper for the oversize (test 6), the percentage of undersize at 5 and 10 microns was about 3 per cent less than that obtained with the complete dispersing apparatus and that at 5 microns the time taken was much longer, namely three and a quarter hours as compared with two hours. On the other hand the difference in the time taken at 10 microns was only five minutes. At 20 and 40 micron cuts the results of tests 3 and 6 are almost identical in each case. It follows that when making "cuts" at the smaller sizes such as 5 and 10 microns, it is necessary to use the complete dispersing apparatus in order to obtain the most accurate results in the shortest possible time. This is shown

TABLE IV—*Comparison of Rates of Elutriation at 5 Microns*

Conditions of dispersal	Initial increased air velocity		
	Standard apparatus, Test 5	Standard apparatus with feeder, Test 6	Complete dispersing apparatus, Test 3
Time taken to complete "cut" hours	3½	3½	2
Average rate of removal of undersize. Per cent per hour	12·9	15·0	26·0

most clearly in Table IV where the total weight of dust less than 5 microns (expressed as a percentage of the whole sample) is divided by the time taken to complete the "cut" in each of the three tests in which short periods of elutriation were adopted (tests 5, 6 and 3). This enables a true comparison to be made of the rate at which the undersize can be removed by each method. Thus the average rate of removing the undersize when using the special apparatus to assist the initial dispersal of the dust is about twice that obtained by the other two methods.

CONCLUSIONS

The experiments have shown the importance of using a suitable method to disperse the dust as discrete particles in the air stream, particularly when using very low air velocities corresponding to particle size limits of say 5 microns.

By using an apparatus which injects the dust gradually into the system and continuously removes the oversize particles from the air stream, it has been found possible to make reliable "cuts" at 5 microns on a sticky type of dust which could not be dispersed by the standard method of test.

When using the special dust-dispersing apparatus and making "cuts" at 5 microns on a free-flowing dust, the average rate of elutriation is twice that obtained when using the standard apparatus.

When using the standard apparatus the rate of elutriation of small particles is considerably improved by introducing an initial period of high air velocity to disperse the dust in the elutriating column.

The advantages of dispersing the dust by the methods described become less as the particle size increases. With the dust examined, the effect was large at 5 microns, but small when making a "cut" at 20 microns and negligible at 40 microns.

The size distribution obtained when using the new methods of dispersal, is sensibly the same as that obtained by the standard method at 10, 20 and 40 microns. It was not possible to make a direct comparison at 5 microns, since it was found that when using the standard method it was impossible to remove more than a small proportion of particles below this size.

ACKNOWLEDGMENTS

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Fatigue Strength of Specimens Containing Preformed Fatigue Cracks

By N. E. FROST, B.Sc.(Eng.), A.M.I.Mech.E.*

Small fatigue cracks have been formed in 1in diameter round bar specimens under conditions of rotating bending by applying a stress above the intrinsic fatigue limit of the material. Direct stress fatigue tests were then carried out on the cracked specimens, employing a wholly tensile stress cycle (minimum tensile stress of cycle 1 ton per square inch). The materials investigated were a 0·15 per cent C mild steel, a nickel chromium steel (EN 26) and an aluminium alloy (B.S. L65). It appeared that for each material a definite fatigue limit existed for the cracked specimens and that a smooth S/N curve was obtained although the specimens did not contain cracks of equal depth. The results are discussed in relation to previous work on similarly cracked specimens tested under completely reversed stress cycles.

IT is well known that a specimen containing a sharp mechanically formed notch, when subjected to fatigue loading, will have a much lower strength than a similar specimen without a notch. Moreover, fatigue cracks will propagate in sheet specimens subjected to a wholly tensile stress cycle at very low alternating stresses if the crack is started from some kind of artificial flaw such as a fine saw-cut or sharp notch.[1] In these cases, failure occurs due to the formation of a crack under the high stress concentration caused by the stress raiser and then the crack subsequently propagating across the specimen. It has also been found, however, for materials such as mild steel and alumi-

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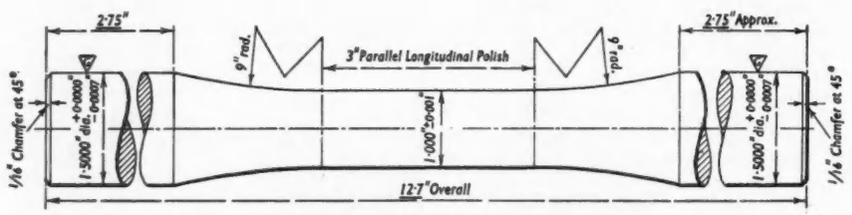

Fig. 1—1in diameter rotating bending fatigue specimen

TABLE I—*Details of Materials Used*

Material	Reference mark	Chemical analysis, per cent	Heat-treatment, deg. Cent.	Tensile strength, tons/sq. in	0·1 per cent proof stress, tons/sq. in	Elongation on 4√area, per cent	Fatigue limit of plain specimens, tons/sq. in
Mild steel	TON	Carbon ... ... 0·15 Manganese ... 0·45 Sulphur... ... 0·014 Phosphorus ... 0·015	Normalise 920	29	22 (yield stress)	30	±14 (direct stress) ±17·5 (rotating bending)
Nickel chromium steel	RSU	Carbon ... ... 0·43 Nickel ... ... 2·64 Chromium ... 0·75 Manganese ... 0·65 Molybdenum 0·58 Vanadium ... 0·05 Silicon ... ... 0·32 Phosphorus ... 0·012 Sulphur... ... 0·012	850 oil quench 650 air cool	63	54	24	±36·5 (direct stress and rotating bending)
Aluminium alloy	MBHQ	Copper ... ... 4·4 Magnesium ... 0·7 Silicon ... ... 0·7 Manganese ... 0·6	505 water quench aged at 160–190	32	28	8	±9·7 (direct stress and rotating bending) at an endurance of 50×10^8 cycles

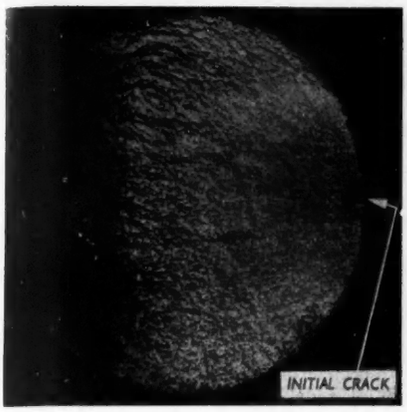

Fig. 2—Mild steel specimen TON 5L

Fig. 3—Nickel chromium steel specimen RSU 15D

Fig. 4—Aluminium alloy specimen MBHQ 2A2

nium alloy B.S. L65 that the notch can cause the formation of a crack which does not necessarily propagate.[2, 3] This implies that the crack is not so serious a strength reducer as the notch.

In contrast to the problem of the fatigue crack started at an artificial stress raiser, is the problem of the strength reduction effect of a fatigue crack which is initially formed in a plain specimen at stresses above the intrinsic fatigue limit of the material itself. Frost and Phillips[4] obtained the fatigue strength under both rotating bending and reversed direct stress of mild steel, nickel chromium steel and aluminium alloy

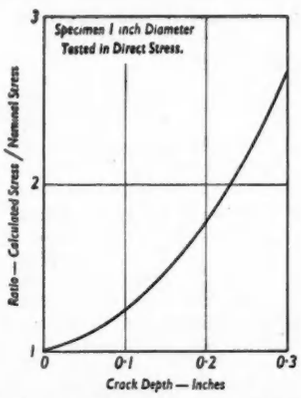

Fig. 5—Curve showing relation of calculated stress along inner edge of crack to nominal stress for varying crack depths

cylindrical specimens containing fatigue cracks preformed at stresses above the intrinsic fatigue strength of the material. It was found that for each material the fatigue strength was approximately the same for both methods of testing and also that it was insensitive to differences in crack depth. However, for both the types of loading used by Frost and Phillips,[4] the load cycle was completely reversed and two alternative assumptions seemed possible regarding the estimated nominal stress range applied to any cracked specimen.

(*a*) On the compression cycle the crack closed up and the full section of the specimen carried the load.

(*b*) The crack did not close up completely in compression and the compression stress reached the same value as the maximum reassessed tensile stress, allowing for the reduced cross-section and non-axiality of loading on the section containing the crack.

The results obtained showed that assumption (*b*) gave the more consistent *S*/*N* curves in spite of the fact that assumption (*a*) appeared the more logical. However, this does not mean that assumption (*b*) is necessarily true as tests carried out under zero mean load cannot differentiate between stress range and maximum tensile stress failure criteria. It can be argued that on the compression cycle no stress concentration due to the crack can occur and, therefore, the tension cycle has the dominating effect.

To clarify these points, tests have been carried out on the same three materials

TABLE II—*Results of Mild Steel Specimens*

All specimens cracked in rotating bending at 1500 r.p.m. and retested in Schenk machine at 1800 cycles per minute.

Specimen	Initial cracking conditions: Stress, tons/sq. in	Initial cracking conditions: Cycles, millions	Reloading conditions: Nominal stress, tons/sq. in	Crack depth, in	Stress correction factor	Reassessed stress along crack edge, tons/sq. in	Equivalent mean stress and range, tons/sq. in	Cycles, millions
TON 5H	±18·2	0·414	1–21	0·03	1·18	1·2 –24·8	13 ±11·8	0·047 B
TON 5J*	±18·2	0·449	1–21	0·02	1·03	1·05–21·65	11·35±10·3	0·109 B
TON 5D*	±18·2	0·450	1–19	0·01	1·01	1·0 –19·2	10·1 ± 9·1	0·309 B
TON 5E	±18·2	0·560	1–17	0·04	1·075	1·1 –18·3	9·7 ± 8·6	0·366 B
TON 5K*	±18·2	0·535	1–15	0·03	1·05	1·05–15·75	8·4 ± 7·35	0·440 B
TON 5L*	±18·2	0·474	1–13	0·03	1·05	1·05–13·65	7·35± 6·3	1·092 B
TON 5D	±18·2	0·450	1–12	0·01	1·01	1·0 –12·1	6·55± 5·55	33·640 U
TON 5F	±18·2	0·520	1–11·5	0·05	1·10	1·1 –12·65	6·9 ± 5·8	0·867 B
TON 5K	±18·2	0·535	1–11	0·03	1·05	1·05–11·55	6·3 ± 5·25	12·289 U
TON 5M	±18·2	0·449	1–11	0·02	1·03	1·05–11·35	6·2 ± 5·15	11·386 U
TON 5L*	±18·2	0·474	1– 9	0·03	1·05	1·05– 9·45	5·25± 4·2	10·033 U
TON 5L	±18·2	0·474	1– 5	0·03	1·05	1·05– 5·25	3·15± 2·1	11·757 U

Estimated fatigue limit 1–12 tons/square inch

* Previously tested at a lower stress. U denotes unbroken. B denotes broken.

TABLE III—*Results of Nickel Chromium Steel Specimens*

All specimens cracked in rotating bending at 1500 r.p.m. and retested in Schenk machine at 1800 cycles per minute.

Specimen	Initial cracking conditions: Stress, tons per square inch	Initial cracking conditions: Cycles, millions	Reloading conditions: Nominal stress, tons per square inch	Crack depth, inches	Stress correction factor	Reassessed stress along crack edge, tons per square inch	Equivalent mean stress and range, tons per square inch	Cycles, millions
RSU 15M*	±40	0·150	1—23	0·01	1·01	1·0 —23·2	12·1 ±11·1	0·139 B
RSU 15K*	±40	0·437	1—21	0·04	1·075	1·1 —22·6	11·85±10·75	0·086 B
RSU 15D*	±40	0·349	1—15	0·09	1·21	1·2 —18·15	9·7 ± 8·5	0·279 B
RSU 15M	±40	0·150	1—14	0·01	1·01	1·0 —14·15	7·6 ± 6·6	10·284 U
RSU 15K	±40	0·437	1—14	0·04	1·075	1·1 —15·05	8·1 ± 7·0	15·487 U
RSU 15J*	±40	0·381	1—13	0·11	1·29	1·3 —16·75	9·05± 7·75	0·978 B
RSU 15C	±40	0·316	1—13	0·17	1·58	1·6 —20·55	11·1 ± 9·5	0·129 B
RSU 15E*	±40	0·305	1—13	0·12	1·33	1·35—17·3	9·35± 8·0	0·637 B
RSU 10J	±40	0·112	1—12	0·17	1·58	1·6 —18·95	10·3 ± 8·7	0·157 B
RSU 15L*	±40	0·178	1—11	0·22	1·91	1·9 —21·0	11·45± 9·55	0·212 B
RSU 15D	±40	0·349	1—11	0·09	1·21	1·2 —13·3	7·25± 6·05	19·688 U
RSU 15E	±40	0·305	1—11	0·12	1·33	1·35—14·65	8·0 ± 6·65	17·673 U
RSU 15F	±40	0·197	1—10	0·22	1·91	1·9 —19·1	10·5 ± 8·6	0·261 B
RSU 15J*	±40	0·381	1—9	0·11	1·29	1·3 —11·6	6·45± 5·15	13·005 U
RSU 15N	±40	0·110	1—9	0·26	2·25	2·25—20·25	11·25± 9·0	0·233 B
RSU 15L	±40	0·178	1—7	0·22	1·91	1·9 —13·35	7·65± 5·75	14·336 U
RSU 15J	±40	0·381	1—5	0·11	1·29	1·3 — 6·45	3·9 ± 2·6	26·123 U

Estimated fatigue limit 1—15 tons per square inch.

* Previously tested at a lower stress. U denotes unbroken. B denotes broken.

TABLE IV—*Results of Aluminium Alloy Specimens*

All specimens cracked in rotating bending at 1500 r.p.m. and retested in Schenck machine at 1800 cycles per minute.

Specimen	Initial cracking conditions: Stress, tons per square inch	Initial cracking conditions: Cycles, millions	Reloading conditions: Nominal stress, tons per square inch	Crack depth, inches	Stress correction factor	Reassessed stress along crack edge, tons per square inch	Equivalent mean stress and range, tons per square inch	Cycles, millions
MBHQ 19A*	±17	0·126	1—11	0·04	1·075	1·1 —11·85	6·5 ±5·4	0·059 B
MBHQ 2A2	±17	0·095	1—7	0·07	1·15	1·15— 8·05	4·6 ±3·45	0·527 B
MBHQ 2A1	±17	0·094	1—7	0·03	1·05	1·1 — 7·35	4·25±3·15	1·606 B
MBHQ 11A2	±17	0·079	1—7	0·16	1·53	1·55—10·7	6·15±4·6	0·068 B
MBHQ 19A*	±17	0·126	1—6	0·04	1·075	1·1 — 6·45	3·8 ±2·7	8·013 U
MBHQ 19C	±17	0·095	1—5	0·07	1·15	1·15— 5·75	3·45±2·3	3·843 B
MBHQ 19B	±17	0·163	1—5	0·08	1·18	1·2 — 5·9	3·55±2·35	3·719 B
MBHQ 17A2	±17	0·099	1—5	0·12	1·33	1·35— 6·65	4·0 ±2·65	1·670 B
MBHQ 16A2	±17	0·139	1—5	0·15	1·48	1·5 — 7·4	4·45±2·95	1·847 B
MBHQ 17A1	±17	0·121	1—4	0·19	1·70	1·7 — 6·8	4·25±2·55	4·598 B
MBHQ 16A1	±17	0·163	1—4	0·20	1·77	1·75— 7·1	4·45±2·7	2·745 B
MBHQ 19A	±17	0·126	1—4	0·04	1·075	1·1 — 4·3	2·7 ±1·6	25·163 U

Estimated fatigue limit 1—5·5 tons per square inch.

* Previously tested at a lower stress. U denotes unbroken. B denotes broken.

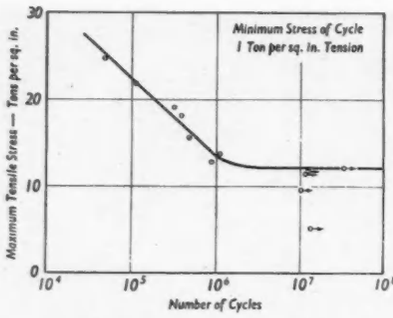

Fig. 6—*S/N* curve for mild steel

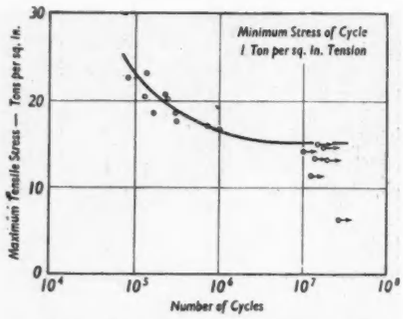

Fig. 7—*S/N* curve for nickel chromium steel

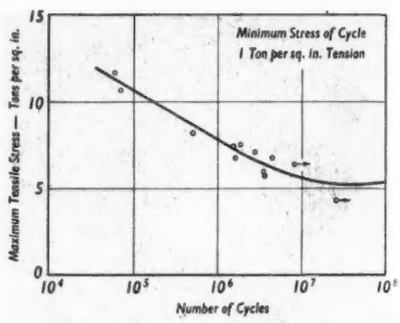

Fig. 8—*S/N* curve for aluminium alloy

employing a wholly tensile stress cycle. This eliminates any uncertainty regarding the closing of the crack for under these conditions the crack will remain open throughout the entire stress cycle.

Experimental Details

The materials used were a 0·15 per cent C mild steel, a nickel chromium steel EN 26, and an aluminium alloy B.S. L65. Full details of their chemical analysis, mechanical properties and heat-treatment are given in Table I. Rotating bending fatigue test pieces of 1in effective diameter with plain cylindrical ends, as shown in Fig. 1, were cut longitudinally from bar material. A small fatigue crack was formed in each specimen, under conditions of rotating bending, by applying a stress above the intrinsic fatigue limit of the material in the manner described by Frost and Phillips.[4] The ends of the specimen were then threaded 1¼in B.S.W. to fit adaptors for a 60-ton Schenck direct stress fatigue testing machine. Fatigue tests on the cracked specimens were carried out at 1800 cycles per minute, employing a wholly tensile stress cycle with a minimum tensile stress of 1 ton per square inch in each case.

Experimental Results

The results of the fatigue tests for the mild steel, nickel chromium steel and aluminium alloy are given in Tables II, III and IV, respectively. The left-hand side of each Table gives the initial cracking conditions while the right-hand side gives the details of the direct stress fatigue tests on the cracked specimens. The nominal stresses applied to the cracked specimens are based on the full diameter of the specimen for, until failure has occurred, no estimate of crack depth can be made. Figs. 2, 3 and 4 show typical photographs of fractured specimens for each of the materials tested ; the extent of the initial crack can be easily seen. After each test the stress was reassessed by making allowance for the increase in stress due to the reduced area and the non-axiality of the loading across the cracked section. It was found from experience that deep cracks had a straight internal edge while smaller cracks had a curved internal edge. In these latter instances the edge was assumed to be straight, and the depth of crack was taken as two-thirds the maximum depth. Since for small cracks, the magnitude of the correction applied to the nominal stress is small, it was considered that the errors incurred by this approximation would be negligible.

The curve shown in Fig. 5 is replotted from Frost and Phillips[4] and gives the ratio of the stress along the inner edge of the crack to the nominal stress for various crack depths. The values of the measured crack depths, the corresponding stress correction factors and the reassessed stresses are given in Tables II, III and IV.

Fatigue *S/N* Curves for the Cracked Specimens

Figs. 6, 7 and 8 show the reassessed maximum tensile stress plotted against the number of cycles for the mild steel, nickel chromium steel and aluminium alloy, respectively. It can be seen that smooth *S/N* curves are obtained for each material tested, irrespective of the fact that the cracks were not of equal depth. This agrees with the conclusion drawn from the earlier work[4] that the strength reduction effect of the crack appears to be insensitive to variations in crack depth. From Figs. 6, 7 and 8 the repeated tension fatigue limits for the three materials are :

Mild steel	1–12 tons per square inch
Nickel-chromium steel ...	1–15 tons per square inch
Aluminium alloy...	1–5·5 tons per square inch

The *S/N* curve for the aluminium alloy was not determined as precisely as for the other two materials, due to shortage of material and the premature breakage of a number of specimens in the adaptors of the fatigue machine.

Discussion of Results and Correlation With Zero Mean Load Tests

Frost and Phillips[4] obtained the following values for the fatigue limits of cracked specimens of similar materials under conditions of zero mean load, i.e. completely reversed stress cycles.

Mild steel	±5·5 tons per square inch
Nickel-chromium steel ...	±13 tons per square inch
Aluminium alloy	±6 tons per square inch

These values, as mentioned in the introduction, were based on a stress range of twice the reassessed maximum tensile stress of each cycle, as this method of assessing the stress range gave the most consistent *S/N* curves.

Considering first the aluminium alloy, the fatigue limit obtained by the present work is 1–5·5 tons per square nch, whilst that under zero mean load is ±6 tons per square inch. This suggests the possibility that the stress concentration due to the crack may only be

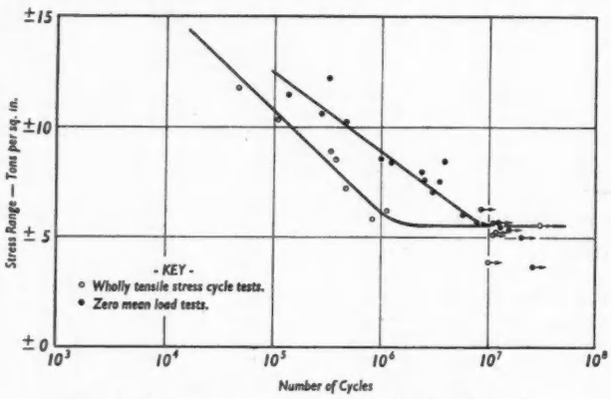

Fig. 10—Stress range v. number of cycles for mild steel

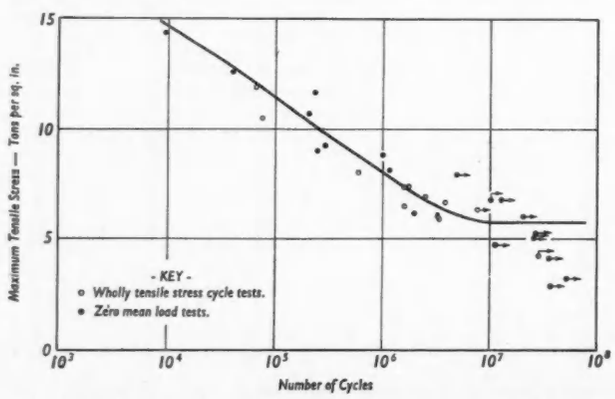

Fig. 9—Maximum tensile stress v. number of cycles for aluminium alloy

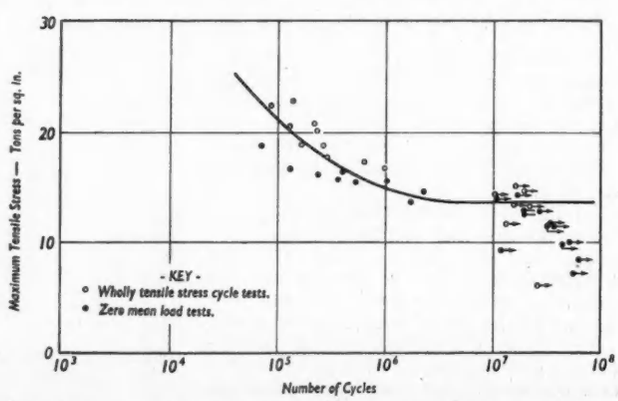

Fig. 11—Maximum tensile stress v. number of cycles for nickel chromium steel

operative on the tensile half of the stress cycle. Fig. 9 shows the maximum reassessed stress on the tensile cycle plotted against the number of cycles for both the zero mean load tests and the wholly tensile cycle tests. It can be seen that the points lie evenly distributed about a single curve.

Considering now the mild steel, the respective fatigue limits are 1–12 tons per square inch and ±5·5 tons per square inch.

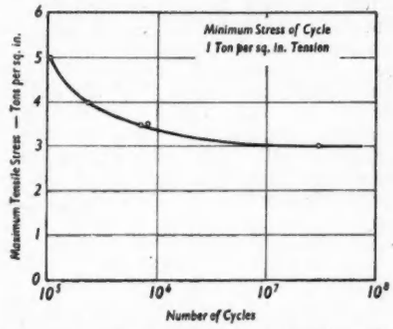

Fig. 12—*S/N* curve for vee-notched aluminium alloy specimens

These figures indicate that the stress range is the same in both cases, as the repeated tension fatigue limit of 1–12 tons per square inch is equivalent to a stress cycle of 6·5± 5·5 tons per square inch. Fig. 10 shows the stress range for the two kinds of loading plotted against the number of cycles. Although two separate curves are obtained, they both have the same fatigue limit of ±5·5 tons per square inch. For any stress range above this value specimens under a wholly tensile cycle fracture sooner than those under zero mean load, due to the superimposed mean tensile stress. It is not unreasonable to suggest that, as the mild steel is considerably more ductile than the aluminium alloy, plastic flow may occur at the tip of the crack on the tensile cycle and allow a stress concentration effect to operate on the compression cycle.

Considering finally the nickel chromium steel, the two fatigue limits are 1–15 tons per square inch and ±13 tons per square inch. These figures suggest that the same argument holds as for the aluminium alloy. Fig. 11 shows the maximum stress on the tensile cycle for both series of tests plotted against the number of cycles. The points lie approximately around a single curve although the repeated tension results all tend to lie above the zero mean load points. As the static elongation value for the nickel-chromium steel is about midway between that for the aluminium alloy and the mild steel, it is possible some slight stress concentration effect may be operative on the compression cycle. This is in accord with the fact that the points are further apart at the highest stresses and tend to converge as the fatigue limit is approached.

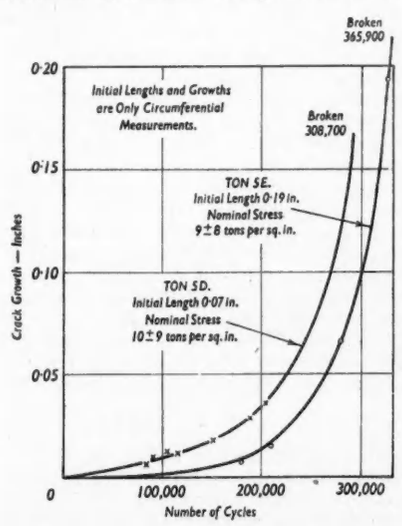

Fig. 13—Curves showing crack growth with number of cycles

Frost and Phillips[4] compared the fatigue limits of cracked and notched specimens of similar materials and showed that the notched specimens could have a lower strength. Lack of information does not allow a similar comparison under conditions of a wholly tensile loading cycle for the two steels, but some results for the aluminium alloy are available. Tests were made on notched specimens of 1·3in minimum diameter and containing a 55 deg. vee notch 0·2in deep with an 0·002in root radius. The minimum stress in the cycle was kept constant at 1 ton per square inch, and Table V

TABLE V—*Results of Fatigue Tests on Notched Specimens of Aluminium Alloy When Subject to a Wholly Tensile Stress Cycle*

Specimen	Nominal stress, tons per square inch	Cycles to fracture, millions
MBCG 11H	1–5	0·106 B
MBCG 11K	1–4	0·231 B
MBCG 2M	1–3½	0·617 B
MBHQ 22G	1–3½	0·799 B
MBCG 2N...	1–3	31·327 U

B denotes broken. U denotes unbroken.

Notch Dimensions

Minimum diameter between roots ...	1·3in
Flank angle	55 deg.
Notch depth	0·2in
Root radius	0·002in

gives the results obtained. Fig. 12 shows the nominal maximum tensile stress plotted against the number of cycles. Although only five points are available and the results must be considered approximate, it is not unreasonable to assume a fatigue limit of about 1–3 tons per square inch. This is about one-half the value obtained for the cracked specimens.

Thus the experimental results show that plain specimens containing fatigue cracks can be stronger than specimens containing mechanically formed notches. It has been suggested that the increase in strength is in some way related to the much steeper stress gradient generated by the crack than by the notch. However, in the cracked specimens residual compressive stresses caused in the cracking process may be an important factor.

Propagation of Cracks

Due to the inherent difficulties of obtaining continuous measurements of crack growth with cylindrical specimens (i.e. only the increase in circumferential length can be measured and no measure of the depth or growth of the crack into the body of the specimen is possible), no serious attempt was made to record crack growth. Crack growth experiments are much more conveniently done on flat plate or sheet specimens. However, for interest, visual inspection with the aid of a low-power microscope of several specimens was made. Typical results are given in Fig. 13, which shows details of the approximate values of the increase in crack length with the number of cycles for two mild steel specimens. It appears that the growth is continuous from the beginning of the tests, although the observations are not accurate enough to show definitely whether or not a dormant period exists. It is interesting to note that although one crack is initially almost three times as long as the other, its growth is similar.

Conclusions

(1) The fatigue limits of pre-cracked cylindrical specimens obtained under a repeated tension loading cycle with a minimum tensile stress of 1 ton per square inch are :—

Mild steel	1–12 tons per square inch
Nickel-chromium steel ...	1–15 tons per square inch
Aluminium alloy...	1–5·5 tons per square inch

(2) The fatigue strength appeared to be insensitive to variations in initial crack depth. This agrees with published results of tests at zero mean load.[4]

(3) Comparison of the above fatigue limits with those obtained under completely reversed stress cycles suggests that for this latter kind of loading : (*a*) for mild steel, the stress range is the criterion of failure ; (*b*) for the less ductile aluminium alloy and nickel-chromium steel, only the tensile half of the stress cycle is effective.

(4) The fatigue limit under a wholly tensile stress cycle of specimens containing mechanically formed notches can be less than that of pre-cracked specimens, i.e. those where an initial fatigue crack is formed in a plain specimen at nominal stresses greater than the intrinsic fatigue limit of the material.

Acknowledgments

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Industry and Technical Progress

FOLLOWING the publication of the report by Professor C. F. Carter and Professor B. R. Williams, entitled *Industry and Technical Progress* (see page 819 of our last issue), an announcement has been made about two forthcoming conferences relevant to it. The first of them will be held at the Royal Society of Arts, John Adam Street, London, W.C.2, on Thursday, June 27, beginning at 9.30 a.m. and going on throughout the day. The subject for discussion is "Capital for Scientific Development : the Problem of its Supply for Industry."

The second conference is to be held at Leeds University on Friday, July 5. It is being arranged by the British Association for the Advancement of Science, and will consider the supply of scientists and technologists for industry. In particular, this conference will discuss the chapter of the report which is devoted to a consideration of some of the problems connected with increasing the supply of trained men and women for industry. They include problems confronting the schools, colleges and universities, such as early leaving, early specialisation, university entrance requirements, university degrees, and the recruiting of science teachers for schools and staff for technical colleges. Some of the problems confronting industry are also to be discussed, including the qualities industry looks for in a scientist or technician, the shortage of scientific staff, salaries, promotion, training schemes in firms, recruitment by large and small firms, efficiency in the use of scientists and technologists by industry and the shortage of draughtsmen.

Technological Humanism

By SIR ERIC ASHBY

We reprint here some excerpts from the annual May Lecture delivered by Sir Eric Ashby, President and Vice-Chancellor, The Queen's University, Belfast, on April 29, before the Institute of Metals. The lecture is of interest just as much to engineers as to metallurgists. It argues not merely that the education of a technologist should include some study of the humanities but that the humanities are an integral part of any technology and are, therefore, an essential constituent of a complete technological education.

THIS long historical digression* enables us to diagnose the present state of higher technological education in Britain. On the one hand, there are grounds for satisfaction : there is no reason to believe that any foreign university can teach the practice and techniques of science and technology better than they are taught in such places as Imperial College or Manchester or Cambridge. Regarded as a preparation for doing nothing but organic chemistry, or non-ferrous metallurgy, or light electrical engineering—in other words, regarded as a production line for highly differentiated experts—there is nothing much wrong with technological education in Britain. On the other hand, grounds for anxiety do exist, for buried at the foundations of our system for educating higher technologists there are two assumptions, both of which are wrong. The first assumption is that the technologist has had a balanced schooling with a thorough grounding in what are vaguely called " the humanities." This assumption may have been justified fifty years ago. To-day it is no longer justified. The would-be technologist has had to decide in his early teens to go up the school on the science side and not on the classical side, and he has to specialise for ever afterwards. No secondary education is so over-specialised as ours in Britain to-day. The second assumption is that the technologist is to become and to remain an expert to serve the manager, never to become a manager himself. This assumption, also, is no longer justified ; and in the Second Industrial Revolution, which is upon us now, it will become an utterly obsolete assumption. Because these two assumptions are still made, the question of including the humanities in higher technological education is still not taken seriously.

Technological Training Abroad

Contrast this with the training being given to technologists in other countries. I quote the purpose of the Massachusetts Institute of Technology : to train men for posts where " a systematic study of political and social relations and familiarity with scientific methods and processes are alike essential." The student at the Massachusetts Institute of Technology must devote a considerable portion of his time throughout all four years of his course to English composition and literature, history, psychology, international relations, and economics ; and these subjects are taught in a way which is relevant to technologists. In the Swiss Federal School of Technology at Zürich, third and fourth-year students include in their course law, economics and management, and there is a Department of General Education with twelve professorships covering foreign languages, philosophy, history, law and political economy. All students must register for at least one course in this department. In the Technical University of Delft, there is a so-called " Studium Generale," which provides lectures on religion, philosophy, music and art ; something similar was already being done there over seventy years ago, in the 1880s. Even technological institutions in the Soviet Union devote some time to the humanities and the social sciences.† The British Commonwealth has not ignored these examples : in the New South Wales University of Technology there is a Department of Humanities, with a full professor at its head. Even some English technical colleges have introduced an element of the humanities into their courses.‡ Nevertheless, universities in Britain are not yet persuaded that the humanities are an essential ingredient in higher technological education. Many universities do indeed arrange opportunities for students to broaden their interests through voluntary attendance at lectures on art and music and the like. This is admirable, but it is a very different thing from recognising certain humanistic studies as an integral part of a technologist's formal higher education.

* The lecturer first reviewed the history of technological education in this country and abroad.

† See N. de Witt, " Soviet Professional Manpower," 1955, Washington, D.C.

‡ " Liberal Education in a Technical Age," 1955, London.

The Inclusion of Humanities

Let us be quite hard-headed about the humanities which should be included in higher technological education. There are four criteria for selecting them. First, they should not include subjects which can and ought to be taught at school. Secondly, they should be taught as genuine humanities ; that is to say, they should deal with the creative and social acts of Man, and particularly with value-judgments about these acts : Man's ideas of right and wrong, of good and evil, of justice, freedom and government. Thirdly, they should be taught in such a way as to be relevant to the contemporary world and to technology. (This does not mean we have to invent new-fangled humanities : nothing could be more relevant to the contemporary world than parts of Aristotle's " Politics.") Fourthly, humanities at this level of teaching should be instruments to enhance the individuality of students, to resist that levelling of differences in taste and personality, that tendency to increase social entropy, which is a melancholy consequence of the modern techniques of mass communication.

Indeed, what is needed is nothing less than a revision of the idea of a liberal education. The *Oxford Dictionary* defines liberal education as education fit for a gentleman. That is still an acceptable definition ; it is the idea of a gentleman which has changed. A century ago, when Britain awoke to the need for technological education, a gentleman belonged to what was called the leisured class. The occupations of his leisure did not require any knowledge of science or technology. Modern gentlemen do not belong to the leisured class. Many of them work something like a seventy-hour week, and more and more of them are finding that their business requires expert knowledge. Dare I suggest, in this audience at any rate, that in order to be a gentleman nowadays, one has to be something of a technologist ?

Humanities an Integral Part of Technology

But technology alone will not make a modern gentleman. And this brings me to the core of my lecture. It is nothing new to suggest that technologists should know something of the humanities. I want to go farther ; I want to suggest that, for the gentleman technologist, certain of the humanities are an integral part of technology. " Technological humanism " is not just a rhetorical phrase : it has genuine content. For technology is inseparable from men and communities. In this respect technology differs from pure science. It is the essence of the scientific method that the human element must be eliminated. Contrary to the assumptions of some people, science does not dispense with values ; but it does eliminate the variability of human response to values. It concerns itself only with phenomena upon which all qualified observers agree. It describes, measures, and classifies in such a way that variation due to human judgment is eliminated. Unlike science, technology concerns the applications of science to the needs of man and society. Therefore technology is inseparable from humanism. The technologist is up to his neck in human problems whether he likes it or not. Long ago, in " Science and the Modern World," A. N. Whitehead saw the essential unity between technology and humanism. Listen to what he said :

" A factory with its machinery, its community of operatives, its social service to the general population, its dependence upon organising and designing genius, its potentialities as a source of wealth to the holders of its stock is an organism exhibiting a variety of vivid values. What we want to train is the habit of apprehending such an organism in its completeness."

The habit of apprehending a technology in its completeness : this is the essence of technological humanism, and this surely is what we should expect an education in higher technology to achieve. How is it to be achieved ? It should be our business in higher technological education to persuade students that they cannot practise technology without continually reflecting upon its social implications, and that some understanding of the humanities is essential to this reflection. For a metallurgist to take a course in general history in order to acquire a little culture is an innocent but not necessarily a very profitable amusement. But if the metallurgist studies the social and economic history of the Industrial Revolution ; if he learns how the making of iron followed the forests across Europe until coal replaced charcoal ; if he realises how mining and the building of railways and canals stimulated the study of geology, and how this in turn brought men face to face with the evidence for organic evolution ; if he considers the effect which the introduction of electric power has had on the distribution and layout of factories, and the effect which aluminium alloys have already had on world transport and the conduct of diplomacy : then history becomes integrated with metallurgy ; his humanism becomes a relevant part of his day-to-day thinking.

Effect Upon a Curriculum

If these arguments are acceptable, the mischievous antithesis between specialisation and general culture disappears.

I must not shrink from the last step. Anyone can blow bubbles about education for an hour. But educational bubbles have

no value unless they can be stabilised, and the only stabilisers are curricula and time-tables. " Very well " (you will be saying), " what does all this involve in (for example) the weekly time-table of a civil engineer in a British University ? " I shall try to tell you. It involves a little more time in the undergraduate course, secured either by cutting some subjects down or by lengthening the course. Since Britain is about the last country in the world to attempt to train technologists in three years from the post-intermediate stage, I would not regard this as a very grave obstacle.

Here are some examples of the choice of courses lecturers might offer to technology students :

(*a*) A course on ethics and jurisprudence, with some discussion of the principles of law and justice (such as might be given by a legal philosopher).

(*b*) A course on industrial and social history of Europe since the seventeenth century, with emphasis on the social effects of technological change (such as is already offered at the Dutch Institute of Social Studies at The Hague).

(*c*) A course on political theory, political institutions, and the history of guilds and trade unions (this would be an opportunity for mediæval as well as modern historians).

(*d*) A course on industrial psychology.

(*e*) A course on sociology and social anthropology.

(*f*) A course on the history of technology, including readings from the classics of science and technology (this might go some way toward meeting one criticism of all present courses on technology, namely, that it is possible to get a first-class honours degree without ever having read a work of genius).

(*g*) A course on linguistics and communication (a development of some of the material contributed to the Communication Research Centre at University College, London).§

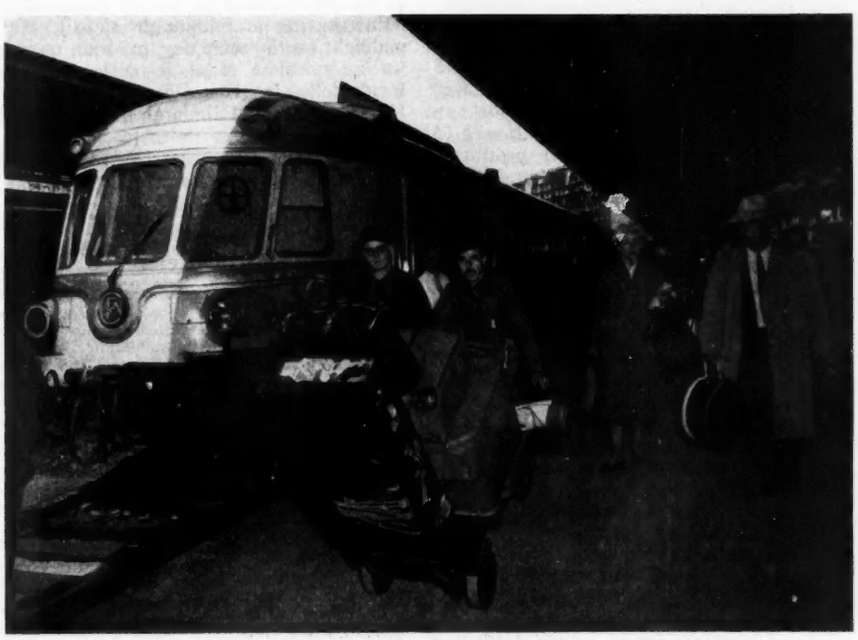
Not every student should take every course. It would be very much better that a student should pursue one rigorous course over a period of (say) two years (with the discipline of reading and essay writing and examination which should be required in such a course) than that he should ramble in a dilettante fashion among several courses. The courses would have to be prepared specifically for technologists, and it is important that they should be used as an opportunity for exercises in communication between students ; for inarticulateness is an occupational disease among technologists ; and it is a disease which I believe could be very much relieved by the simple prophylactic treatment I have outlined.

§ " Studies in Communication," 1955, London.

Autorail Express Trains Between Paris and Zurich

Contributed

IN THE ENGINEER for October 27, 1950, there is an account of the " Autorail Rapide " services then recently introduced between Paris (Gare de l'Est) and Basle. Together with information as to the equipment of the railcars and the configuration of the route, details were given of two journeys, one made by de Dietrich railcar in the eastbound direction and the other by Renault railcar in the westbound direction. In each of these railcars the power was provided by two engines driving through four-speed gearboxes, the gear changes being made electro-pneumatically. Stopping only at Belfort and Mulhouse the inclusive actual time on the eastbound journey (a distance of 526km) was 327 min, 20 sec, the corresponding average speed being 96·4 km.p.h. (60 m.p.h.). On the westbound journey (again stopping at Mulhouse and Belfort) the inclusive actual time was 321 min, 30 sec, representing an inclusive average speed of 100 km.p.h (61 m.p.h.). Full details of these railcar runs as well as information covering contemporary timing between Paris and Basle with steam-hauled trains are given in the issue above referred to and need not be recapitulated here, the purpose of the present article being to describe some important changes which have lately taken place in the equipment and running of the " Rapides " on the Eastern Region of the S.N.C.F.



Arrival of the " Trans-Europe " at the Gare de l'Est

By the introduction of the " Trans-Europe Express " services, certain " Autorail Rapides " passing over the Eastern Region now penetrate to Zürich (Hbf), and during June 1956 such a service was introduced between Paris (Est) and Zürich. The eastbound train leaves Paris at 18.30 and is due in Zürich at 29 min past midnight, there being intermediate stops at Troyes, Chaumont, Vesoul, Belfort, Mulhouse and Basle. Westbound, the train leaves Zürich at 6.44 a.m., and calls at Basle, Mulhouse, Belfort, Vesoul, Chaumont, and Troyes, reaching Paris (Est.) at 12.55. First-class fares must be paid plus a supplement, accommodation being limited. On the occasion of the westbound run detailed in Table I, the train from Zürich consisted of two coaches, one a motor coach built by de Dietrich et Cie., Niederbronn (No. 79.885-1956), the other (a trailer) built (1956) by Brissonneau et Lotz, Creil. Each coach is mounted on two four-wheeled bogies, both are painted red, their leading particulars being as follows:

	Motor coach	Trailer
Length over buffers	87·37ft	83·76ft
Weight empty	48·23 tons (m)	31·68 tons (m)
Number of passengers	39	42

Leaving Zürich the motor coach is the rear coach.

The power is provided by a V-twelve-cylinder MGO-12VSH engine of 825 h.p., the transmission being through " Mekydro " four-speed (and reverse) gearbox and torque converter driving on to two of the four axles of the motor coach. It will be noted that as the tare weight of the two-car train is 79·91 tons, the weight per passenger seat is 0·99 tons. The power being 825 h.p. and the tare weight 79·91 tons, the ratio of power to weight is 10·32. The time allowed from leaving Zürich (Hbf) to stopping at Basle (S.B.B.) is 64 min and the distance being 89km (55·3 miles) the average speed is 83·4 km.p.h. (52 m.p.h.). It must be remembered that in passing from Zürich to Basle the train climbs to the summit at Effingen, where the altitude is 461m (1512·5ft) above sea level. (Note : In the reverse direction the east bound train (No. 47) leaves Basle at 23.30 and is allowed 59 min for the 89km to Zürich. The average speed is thus 90 km.p.h.)

The two-car train left Basle at 8.04 (booked departure time 8.00) reaching Mulhouse (34km) at 8 h 25 min 30 sec. Here, three further coaches (painted green) were added, one a motor coach (de Dietrich et Cie., No. 79272-1955) similar to the motor coach commencing at Zürich, the other two coaches being trailers built (1956) by Brissonneau et Lotz. The coaches connected at Mulhouse were so coupled as to provide a motor coach at each end of the five-coach train, the number of passenger seats being increased (as from Mulhouse) to 204, the train continuing in this formation to Paris. The total tare weight of the five-coach train was 191·5 tons (English) the corresponding weight per passenger seat being 0·94 ton. Since the total power becomes $825 \times 2 = 1650$ h.p., the ratio of power to weight is reduced from

10·32 in the two-car train to 8·6 in the five-car train. It is to be remembered that on the journey from Basle to Paris there are no obstacles so formidable as that presented—between Zürich and Basle—by the ascent to the Bözberg tunnel between Schinznach-Dorf and Effingen. Basle (S.B.B. Bahnhof) is at an altitude of 277m (909ft) above sea level and Belfort is at 359m (1178ft), the summit of the line from Basle to Paris being reached beside kilometre post 433 (between Bas-Evette and Champagney) where the altitude is 390m (1280ft) this comparing with 461m (1512·5ft) at Effingen. Leaving Mulhouse at 8 h 32 min 15 sec (5 min 15 sec late) the train reached Belfort in 27 min, 15 sec (average start-to-stop speed 108 k.m.p.h.) and after a very rapid ascent from Belfort to Champagney, stopped in Vesoul at 9 h 35 min 40 sec. From Table I it will be noted that between Vesoul and Chaumont the average speed start to stop was 118 km.p.h. (73·2 m.p.h.), the distance covered including the climb from La Ferte-sur-Amance (kilometre post 327) to the summit at kilometre post 303 (altitude 1172ft) between Chalindrey and Langres, over which stretch the gradient ranges from 1 in 170 to 1 in 156. Passing kilometre post 350 at 9 h 52 min 45 sec the speed was 126 km.p.h. and it varied very little thence past La-Ferte-sur-Amance, Hortes and Chalindrey, kilometre post 300 (east of Langres) being passed at 10 h 16 min 40 sec, the time taken to cover the 50km stretch—which includes the ascent from Charmoy to Chalindrey—being 23 min, 55 sec, an average speed of 125·4 km.p.h. (77·87 m.p.h.). Traversing the station at Langres (298km from Paris) one thought of its famous townsman Denis Diderot and of what he might have added to his "Encyclopédie" had he seen these five coaches vanishing over the Plateau de Langres at 125 km.p.h. The line falls gently, from Langres to kilometre post 270 at Luzy, between which station and Chaumont there is an ascent of about 6km at 1 in 166. The altitude of the line at Chaumont (kilometre post 262) is 1033ft. From Chaumont to Troyes the start-to-stop time for the 96km was exactly 50 min, an average speed of 115·2 km.p.h. The booked time is 1 min faster, calling for an average speed of 117·57 km.p.h. which is the fastest booking by this train between any two advertised stopping places. The line falls on easy grades from Chaumont to Troyes (altitude 372ft) though there is a climb of 10km from Arsonval-Jaucourt to Vauchonvillers, five of which kilometres are at the rate of 1 in 166. At kilometre post 234 the line passes through Clairvaux with its memories of St. Bernard, the district here having been a haunt of robbers (*Vallis absinthialis*) until after St. Bernard had reformed the entire region, it became known as *Clara vallis* whence Clairvaux. Troyes (the Roman *Trecensis*) was reached at 11 h 27 min 30 sec, the duration of the stop here being only 45 sec, the train leaving at 11h 28 min 15 sec, 3 min 15 sec late.

For the 167 km (103·7 miles) from Troyes to Paris train No. 40 is allowed 90 min, calling for an average speed of 111·3 km.p.h. (72·65 m.p.h.). The line is an easy one, the only appreciable obstacle being the ascent from Flambouin to kilometre post 77, a distance of 18km over which the gradient is at the average rate of about 1 in 166. From kilometre post 77 there is a good run in to Paris, particularly over the last 27km from Emerainville. The fastest 50km stretch on the journey was accomplished between kilometre post 100 and kilometre post 50, which includes the climb from Flambouin to Maison-Rouge. The time occupied was 23 min 30 sec, corresponding to an average speed of 127·66 km.p.h.=79·27 m.p.h. For the last 50km into Paris the time taken was 27 min, 45 sec, the run in from Rosny-sur-Bois being at reduced speed thus avoiding too early arrival, indeed, from Pantin into the terminus the speed was little more than a crawl, the train coming to rest at exactly 12.54, just one minute before time. It will be noted that the time from leaving Troyes (dead start) to arriving (dead stop) in Paris (distance 167 km=103·7 miles) was 85 min, 45 sec, representing an average speed of 117 km.p.h.=72·65 m.p.h., this notwithstanding a protracted speed reduction (to dead slow) at Romilly and the slow run in from Rosny-sur-Bois to the Gare de l'Est. Regarding the eastbound "Autorail Rapide" service, Table II gives the details of the timing Paris–Zürich as set forth in the official timetable. It should be explained that at Mulhouse, the composition of the train is reduced to one motor-coach and one trailer. The time allowed from leaving Paris to arrival at Basle is 295 min for the 526 km, this being the same as for the corresponding run westbound. Onward to Zürich (89km) 59 min are allowed eastbound as against 64 min westbound.

Examination of Tables I and II will show how, by the introduction of the new services, the passenger is able to leave Zürich at 6.44; reach Paris at 12.55; spend 5 h and 20 min in Paris and return on the train which, leaving the Gare de l'Est at 18.20 is due in Zürich at 29 min after midnight. Breakfast and lunch are served on the westbound train and dinner on the eastbound. The total distance covered is 1230km (764 miles) which is only 22 miles less than the return distance between London (King's Cross) and Edinburgh (Waverley). The quality of the performance becomes apparent by noting how return bookings at the same average speed on the route London-Edinburgh would enable a passenger from Edinburgh to travel to London, spend say five hours there and be home again in Edinburgh shortly after midnight on the same day, his train making six intermediate stops in each direction. Incidentally, the East Coast route between King's Cross and Edinburgh has no summit at altitudes such as those reached by the Bözberg tunnel in Switzerland and in the climb to Champagney near Belfort.

TABLE I—*Diesel-Mechanically Hauled "Rapide" Basle to Paris (Est), October 25, 1956 (Train No. 40)*

	Km from Paris	Booked time	Actual time	Intermediate distance		Intermediate time		Intermediate/average speed		
						Booked	Actual	Booked	Actual	
		h. m. s.	h. m. s.	km	miles	min sec	min sec	km.p.h.	km.p.h.	m.p.h.
Dep. Basle	526	8 00 00	8 04 00							
Arr. Mulhouse	492	22 00	25 30	34	21·1	22 00	21 30	92·3	95	59
Dep. Mulhouse		27 00	32 15							
Arr. Belfort	443	55 00	59 30	49	30·4	28 00	27 15	105	108	67
Dep. Belfort		56 00	9 00 20							
Arr. Vesoul	381	9 30 00	35 40	62	38·5	34 00	35 20	109·4	105·26	65·30
Dep. Vesoul		31 00	36 30							
Arr. Chaumont	263	10 34 00	10 36 30	118	73·2	63 00	60 00	112·5	118	73·2
Dep. Chaumont		35 00	37 30							
Arr. Troyes	167	11 24 00	11 27 30	96	59·6	49 00	50 00	117·57	115·2	71·5
Dep. Troyes		25 00	28 15							
Arr. Paris (Est)	0	12 55 00	12 54 00	167	103·7	90 00	85 45	111·33	117	72·65

Notes:
Distance, Basle–Paris (Est) ... 526km (327 miles)
Inclusive journey time (booked) ... 295 min
Inclusive journey time (actual) ... 290 min
Inclusive average speed, Basle–Paris (booked) ... 107km.p.h. (66·49 m.p.h.)
Inclusive average speed, Basle–Paris (actual) ... 108·8km.p.h. (67·6 m.p.h.)
Actual average speed, Vesoul–Chaumont ... 118 km.p.h. (73·27 m.p.h.)
Actual average speed, Troyes–Paris ... 117km.p.h. (72·65 m.p.h.)
Maximum observed speed on journey ... 133·3km.p.h. (82·83 m.p.h.)
Total time standing at stations (booked) ... 9 min
Total time standing at stations (actual) ... 10 min. 10 sec

This train "Triebwagenzug" commences at Zürich, being due to leave the Hauptbahnhof there at 6.44 and to arrive Basle at 7.48. The time allowed for the distance of 89km (55·3 miles) is thus 64 min.
At Mulhouse three additional coaches (one a motor-coach) were attached, and in this form the train completed the journey to Paris

TABLE II—*Diesel-Mechanically Hauled "Rapide" Paris (Est) to Basle, October, 1956 (Train No. 47)*

	Booked time	Intermediate distance		Intermediate time (booked)	Intermediate (booked) average speed	
	h. m.	km	miles	min	km.p.h.	m.p.h.
Dep. Paris (Est)	18 20					
Arr. Troyes	19 46	167	103·7	86	116·5	72
Dep. Troyes	19 47					
Arr. Chaumont	20 38	96	59·6	51	112·8	70
Dep. Chaumont	20 39					
Arr. Vesoul	21 41	118	73·2	62	114	70·9
Dep. Vesoul	21 42					
Arr. Belfort	22 17	62	38·5	35	106	66
Dep. Belfort	22 18					
Arr. Mulhouse	22 46	49	30·4	28	105	65·2
Dep. Mulhouse	22 50					
Arr. Basle	23 15	34	21·1	25	81·6	50·7

Notes:
Distance, Paris (Est)–Basle ... 526km (327 miles)
Inclusive journey time (booked) ... 295 min
Inclusive average speed (booked) ... 107km.p.h. (66·49 m.p.h.)
Total time (booked) standing at stations ... 8 min
This train terminates at Zürich and is booked to leave Basle at 23.30, reaching Zürich (Hauptbahnhof) at 0.29. The booked time from departure Basle to arrival at Zürich is thus 59 min, and as the distance is 89km, the average speed is 90·5km.p.h. Only two cars (one motorised) run through from Basle to Zürich.

Book of Reference

Surface Water Year Book of Great Britain, 1954–55. H.M. Stationery Office. Price 15s. —*The Surface Water Year Book of Great Britain* contains comprehensive records of run-off and rainfall in river basins and reservoired areas in Great Britain. This volume contains records of 116 gauging stations compared with 102 in the last. The positions of these stations are indicated on a map. A table showing the duration of flows of various magnitudes, and two records of natural water temperatures are also included. The period covered by this book includes the very dry summer of 1955, and in many cases lower discharges were recorded at the stations reported in the year book than ever before.

Reduction in the size and the cost of the present volume necessitated the omission of either the daily mean discharge tables or the monthly analysis tables. Inquiry among representative users of the year book revealed an overwhelming preference for the monthly analysis tables which have therefore been retained. Hydrometric records of "reservoired areas" have been summarised on a single page.

LITERATURE

Book Reviews

The Fatigue of Metals. By MEMBERS OF THE INSTITUTION OF METALLURGISTS, 4, Grosvenor Gardens, London, S.W.1. Price 25s.

THE Foreword to this publication states that the five lectures it contains were delivered, in October, 1955, at the ninth " Refresher Course " of the Institution of Metallurgists.

In the first lecture, Dr. Holden contributes an interesting essay, primarily on the more basic aspects of deformation and fracture under cyclic stresses. Published researches using optical and X-ray examinations are very briefly—and, perhaps, somewhat selectively—reviewed, major discussion being devoted to " dislocation theory." Although the lecturer gives the impression that he is numbered among the " converted," his presentation is refreshingly and unusually restrained. The conception of bodily translation of lattice vacancies through a solid metal and their piling up to form a microcrack is certainly the simplest conception of fatigue fracture that has ever been advanced. But many find this explanation just a little too naive and request definite experimental evidence in place of a brittle structure of progressive assumptions ; it is a relief to find that the lecturer also feels the need for such evidence.

Mr. Forrest contributes a thoughtful survey of the observed effects of notches and other forms of stress concentrations on fatigue strength, on notch sensitivity, " non-propagating " cracks and various kinds of surface finish. His findings are concisely summarised and expressed in his own words : " The only general conclusion which can be reached from this survey is that the behaviour of materials with respect to notches and surface finishes is so complicated and related to so many variables that we are still a long way from being able to estimate the strength of complicated engineering components from fatigue tests on normal laboratory specimens. Where design against fatigue is necessary, we have still only two methods of approach. One is to have a big background of experience and the second is to test actual components under conditions as near those of service as possible. On the other hand, as we grow in understanding of the principles lying behind the observed phenomena we are in a better position to deal with fatigue problems when they arise."

An interesting, if purely descriptive, review of the structural aspects of fatigue in aircraft is the subject of the lecture by Dr. Walker. If his introductory remark is to be taken at its face value, i.e. that " nearly ten years ago, there became reasons to suspect that structural fatigue might in time become a major problem in aviation," the recognition of this obvious trouble, by the Royal Aircraft Establishment, was truly tardy. The lecturer briefly discusses the external loading actions due to normal flight, manœuvres and gusts ; the stress concentrations caused by discontinuities, changes in form, transfer of load at joints and junctions of members ; also, the effects of pressurisation. Some interesting photographs show full-sized tests on joints, on a wing assembly and on a complete aircraft with pressurised cabin.

Corrosion-fatigue is reviewed and discussed by Dr. Waterhouse. Commencing with the nature of corrosion, as such, the principal features of corrosion-fatigue are described. Some typical results from the publications of various researchers are presented and discussed. Although fretting-corrosion is not usually treated as an aspect of corrosion-fatigue, a section on that form of attack makes a very useful addition to an interesting lecture.

Lastly, in the fifth lecture, on the effect of temperature on the fatigue strengths of metals, Mr. Frith presents the starkly factual. Some brief introductory paragraphs deal with types of testing machines and test procedures. The lecturer had collected a mass of published data, relating to the fatigue properties, at various temperatures, of a wide range of ferrous and non-ferrous metals and alloys. These data are reproduced in the form of sixteen extensive tables. No doubt, very useful for subsequent reference purposes, this material must have been very difficult to present—or absorb—in lecture form.

The Institution of Metallurgists has, presumably, issued these lectures in printed form for those of its members who attended the Llandudno refresher course as a souvenir of a pleasant occasion. They contain little, if anything, that is original in fact or thought and cannot be recommended to the general reader, for whom, in fact, they were never intended. The remarkable number of review lectures of this type that have been delivered in this country during the last few years indicates the general interest in the subject, which is certainly not to be regretted. Unfortunately, during that period the important contributions to new knowledge from inspired and skilful research have been deplorably few and far between. The whole subject of the fatigue of metals was thoroughly reviewed, last autumn, at the international conference organised by the Institution of Mechanical Engineers, leaving much to be digested and applied by the researcher, designer and development engineer. May one suggest that a reasonable " moratorium " on repetitive reviews be now agreed and more attention concentrated on really worth-while research ?

Aircraft Hydraulics : Volume I, Hydraulic Systems. Edited by H. G. CONWAY, M.A., M.I.Mech.E., F.R.Ae.S. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 35s.

THIS volume, the first of three in a series, is published under the authority of the Royal Aeronautical Society, and was directed by its Hydraulics Sub-Committee. It was edited by Mr. H. G. Conway, a distinguished hydraulics engineer and now a director and the chief engineer of Short Brothers and Harland, Ltd. It is introduced by a Foreword from Mr. E. T. Jones, president of the Royal Aeronautical Society. Apart from Mr. Conway, who contributes one chapter himself, the other authors are all senior technical members of such firms as Dowty, Messier, Lockheeds, and Vickers-Armstrongs.

To pay 35s. for a book of only 144 working pages one must expect a lot of compressed value, and it would appear to be beyond the pocket of the ordinary student or junior technician, unless he has an adequate grant, or else a long-suffering librarian to encourage his interest. Nevertheless, it should be considered indispensable for such people. Naturally, in a book by diverse authors, there must be a certain overlapping, but such overlaps as there are would seem to serve as hammer blows to drive essential points well home. Basically, the datum level assumed of its readers is that of a second-year university or O.N.C. student in applied mathematics. There is nothing cryptic about the explanatory matter which is well written and consistently practical. Expert specialists sometimes find it difficult to write down to a junior audience. There is no evidence of this in the book.

The chapters in this Volume I are devoted to fluids ; hydraulic theory ; performance problems of pipes and components; systems; circuits ; and the installation, operation, and testing of hydraulic systems. Volume II, which we eagerly await, will deal with component design, and it will range from gland packings to valves and servos. Volume III is to be entitled *Landing Gear Design.*

There may be misprints (and it is part of a reviewer's stock-in-trade to look for them), but we have not spotted any of real significance or which could not be straightened out by an intelligent reader. In spite of the Defence White Paper and the forecasted eclipse of military aircraft by guided weapons, the commercial aircraft is now taking a leap forward to become the liner or even the tramp steamer of the future. There will be an ever-increasing need to develop lighter, more efficient, and more reliable hydraulic systems. They still maintain their lead over electrical or pneumatic systems for most of the airborne auxiliary services. But one reads too often of undercarriage and high-lift flap mechanical failures which must be due to careless design or maintenance. It is, therefore, all the more gladdening to find this book, which at first sight appears theoretical, emphasising so many practical points of design, maintenance and inspection. Whilst on the one hand, it discusses the chemical and physical properties of hydraulic fluids, their surface tension and viscosity, on the other, it gets down to such worldly matters as the use of hacksaws in cutting pipes, and the dangerous effects of grit and swarf.

Oil Fuel Applications. By A. T. HENLY. Crosby Lockwood and Son, Ltd., 26, Old Brompton Road, London, S.W.7. Price 35s.

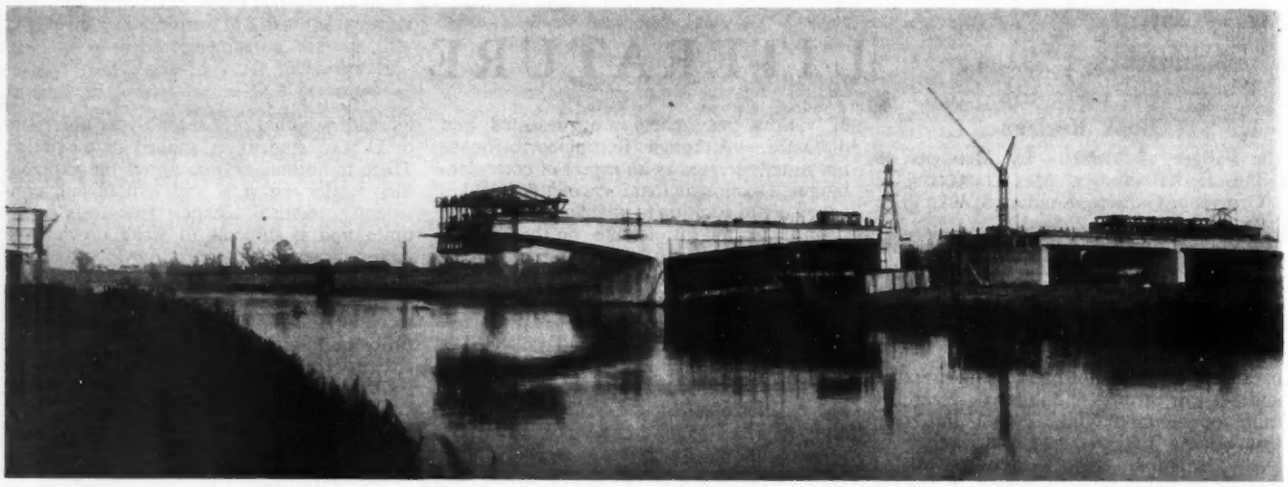
THIS is a new book which covers the whole field of oil firing, both for domestic and industrial heating applications, and as such serves as a reference work for architects and heating and plant engineers. The book is essentially practical and presents a survey of all kinds of oil burners, oil-burning systems and associated equipment, and also of application problems. Chapters deal with oil fuels, oil storage problems and pipelines, and attention is paid to automatic controls, packaged oil-firing units and maintenance questions. In addition to the purely practical, certain design problems are considered, including combined diesel-generator and waste heat recovery plants.

Books Received

Instrument Technology. Volume III, Telemetering and Automatic Control. By E. B. Jones. Butterworths Scientific Publications, Ltd., 88, Kingsway, London, W.C.2. Price 40s.

Practical Geometry and Engineering Graphics. Sixth edition. By W. Abbott. Blackie and Son, Ltd., 16/18, William IV Street, Charing Cross, London, W.C.2. Price 22s. 6d.

Motion Economy and Work Measurement. Second edition. By Robert Lee Morrow. The Ronald Press Company, 15, East Twenty-Sixth Street, New York, 10, N.Y. Price $7.50.



Construction of the Clifton Bridge as seen from the northern bank of the River Trent some weeks ago. The gantry for constructing the main span cantilever, scaffolding for the anchor arms, and the Bailey bridge structure for placing the beams of the approach spans and the suspended span can be seen

Progress of the Clifton Bridge, Nottingham

Very rarely since the war have we been able to record the erection of new bridges of any considerable importance, built in this country. As more emphasis is given to motor roads, however, the number of works of this kind is likely to increase. Here we describe a graceful bridge in prestressed concrete due to be completed at the end of the year.

THE Clifton road bridge over the River Trent at Nottingham, various aspects of which are depicted in the accompanying illustrations, is now well on the way towards completion. The cantilevers and approach spans on the south side are substantially finished, as far as the principal structure is concerned, and the large post-tensioned beams of the suspended span are being cast on this part of the work, while construction of the north cantilever proceeds. The bridge is to serve in the first place for local communication across the river, but it forms part of a trunk road scheme, and it is expected that later on a similar bridge will be built next to it, to carry the second carriageway which will then be needed.

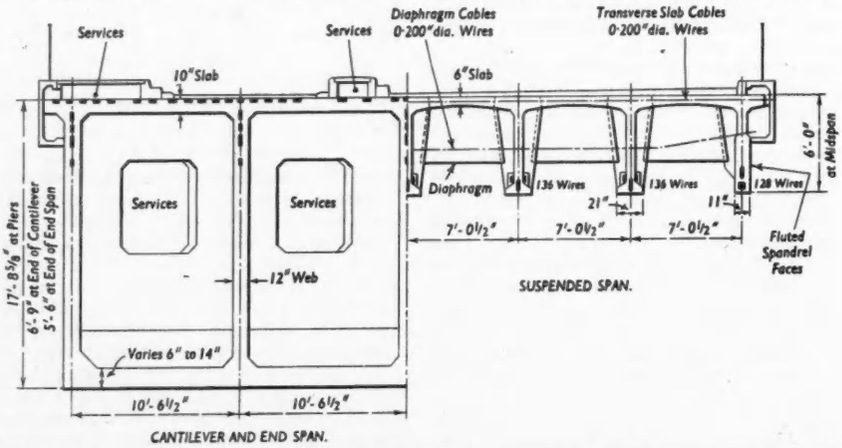
The main span of the bridge is 275ft, consisting of two cantilever arms, each of 87ft 6in, and a suspended span of 100ft. It is flanked on each side by "balancing" cantilever spans, each of 125ft. On the south side there is, in addition, a viaduct of three spans of approximately 90ft each. The approach embankment on the north side is opened at a distance of 1000ft from the river by a viaduct comprising three 40ft spans. Because of flooding, a model study of the site was made by the Trent River Board to determine the effects of restricted flow across the low-lying areas on both sides of the river, and the design was based on the flow requirements thus obtained.

Detailed model studies for structural design were also conducted at the laboratories of the Cement and Concrete Association. A model, one-fiftieth full size, constructed in "Perspex," was tested to determine the effect of the skew; calculations for deflection, based on a "square" section, were compared with the actual deflections induced in the model. A series of load-deflection and prestress-deflection tests were conducted, together with "shear centre" tests, to establish, for various positions of load, the transverse positions of resultant reaction at the end of the end spans.

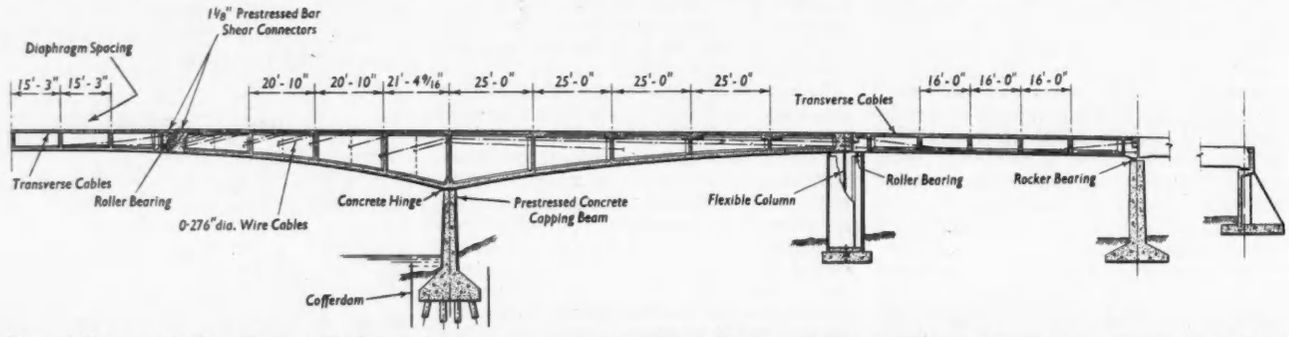
The general form of the bridge is clearly shown, together with leading dimensions, in the two drawings. The abutments at each end of the three principal spans are of cellular reinforced concrete construction, but the two piers are solid; they are founded on reinforced concrete piles and they have a prestressed capping beam on which the superstructure bears.

Transverse diaphragms are at 25ft intervals in the end spans, and 21ft in the river cantilevers. The "flexible" column shown carrying the end of the balancing cantilever is of prestressed concrete. It experiences load reversal according to the live load conditions on the bridge, and is *encastré* at its top and bottom supports, so that it resists temperature movement of the bridge (i.e. horizontal movement of one support relative to the other) flexibly; this arrangement eliminates angular change, and hence unwanted variations in cable stresses, where the cables pass in to and out of the column.

The bridge is designed for the standard loading specified by the Ministry of Transport and Civil



Details of the "box" structure of the cantilevers and of the post-tensioned beams of the suspended span are shown. The bridge carries one 22ft carriage-way, a 9ft cycle track and a 5ft 6in footpath



Clifton Bridge, over the River Trent, at Nottingham, is a prestressed concrete structure with a central span of 275ft. The central span comprises two cantilever arms and a suspended span. The cantilever anchor arms each span 125ft, and there are three further spans of about 90ft each on the south bank side

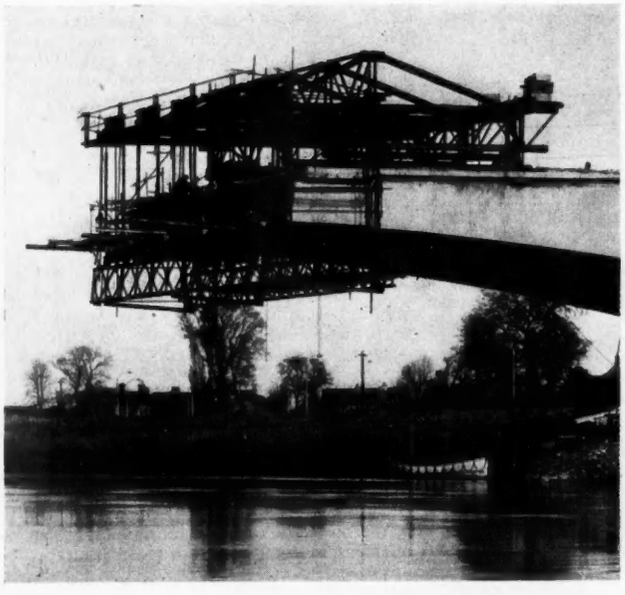
Aviation for trunk roads, including abnormal load, for which a load of 180 tons is stipulated. Detailing work in the design was especially onerous, because of the combination of the skew and the curved form of the structure. Redesign of the detailing for the prestressing cables was also needed when it was decided (after the tendering stage) that the river cantilevers were to be erected by cantilevering out successively in 10ft sections, using an overhanging gantry to support the shuttering. As each section of the cantilever is completed, a sufficient number of prestressing cables is available for anchoring at that point, to give adequate strength to support the next 10ft stage. The gantry is shown in the illustration below. A point of special interest is that hydraulic jacks are built into it to adjust the hangers carrying the shuttering at its outer end. At one setting of the gantry, concrete is placed in several lifts, and as the dead load on the gantry increases, deflections can be removed, by these jacks, thus eliminating any " locked-up " stresses in the completed structure due to construction. Prestressing—which is according to the Magnal-Blaton system—is applied through cables in the deck slab and in the webs ; where necessary, the wires of the deck slab are designed to curve into webs for anchoring. The end cantilevers were, of course, built on falsework before construction of the river cantilevers was started.

The 100ft suspended span consists of seven T-beams. They are being cast on the deck of the section already completed, and are partially prestressed at this stage. One of the illustrations also shows the Bailey bridge device used to place these beams in position as well as the beams of the viaduct spans on the southern side. The 100ft beams will be supported on roller bearings at one end, and rocker bearings at the other ; 1¼in diameter prestressed bar shear connectors will be incorporated at these supports, as indicated on the drawing. The deck slab and transverse diaphragms linking the beams will be cast in-situ, after which further longitudinal prestress and transverse prestress will be applied.

The general construction of the three 90ft " viaduct " spans is similar to that of the suspended span just described. However, the main beams of the central span of the three were cast in-situ, as the first stage of superstructure construction, and subsequent main beams were cast on this span and moved into position with the Bailey gantry. The three 40ft spans of the north viaduct, which, it may be recalled, forms a flood break in the approach embankment, are also somewhat similar, but are prestressed by the Lee-McCall system.

The specifications for the main bridge called for a concrete strength of 6000 lb per square inch at twenty-eight days, but we understand this strength is often achieved after only seven days. The architectural treatment of this high-quality concrete, for which we understand the consulting engineers also carried responsibility, is noteworthy. The spandrel surfaces of the main spans have been cast with a fluted shutter and no further decorative finish will be applied ; the bridge will, however, be capped with a precast " fascia," which will fit over the top flange of the structural concrete, and will be cast with white cement and exposed white aggregate, to contrast with the plain concrete texture of the fluted surface below.

The cost of the Clifton bridge and approaches is given as about £440,000 The city engineer and surveyor of Nottingham is Mr. R. M. Finch, M.I.C.E., and the consulting engineers for the main structure are Messrs. R. Travers Morgan and Partners. The main contractor is James Miller and Partners, Ltd.



Clifton Bridge. Gantry for constructing cantilever arms. As concrete is placed, deflection due to increased load is taken up by jacks, so that the " green " concrete remains unstressed and to the correct line. The fluted finish on the spandrel walls may be noted ; a capping beam in white concrete will contrast with the fluting in the finished structure

Centenary of Crumlin Viaduct

WE have received from the Western Region of British Railways some details of the Crumlin Viaduct, which has now been in use for a hundred years. The viaduct was constructed on the Taff Vale extension of the Newport, Abergavenny and Hereford Railway, which at that time formed the Newport section of the West Midland Railway. It cost only £41 7s. per foot run to construct, we are informed, a remarkably low figure even for those days.

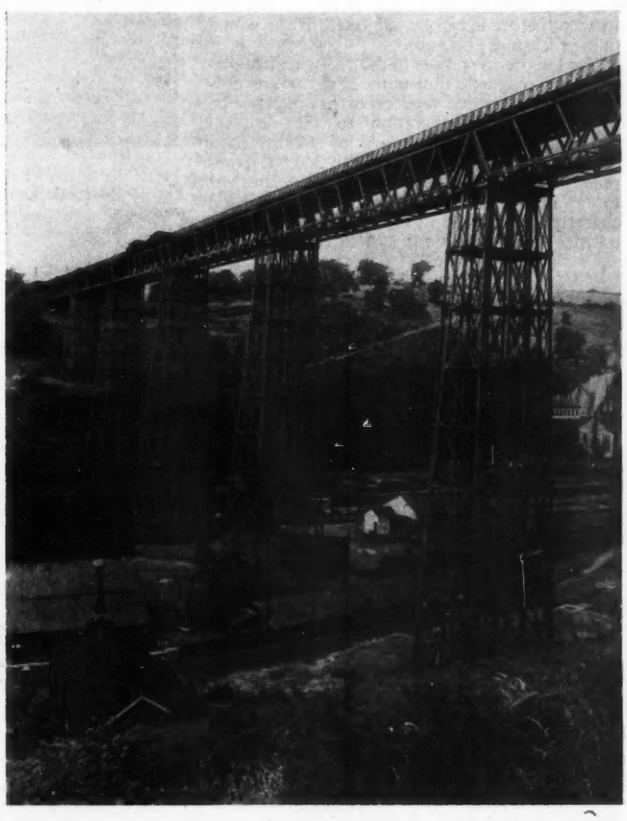
The viaduct is in two parts, one of seven spans, the other of three, separated by a short distance less than the length of one of the spans. All the spans are " deck " spans, 150ft long, each consisting of four pin-jointed riveted wrought iron Warren trusses. The spans are supported on piers each made up of fourteen 12in diameter cast iron columns braced together. The total length including masonry abutments is 1658ft ; the greatest height from the bottom of the foundations to the top of the handrail is 208ft.

Thomas William Kennard was the engineer, and his design, made in competition with several other tenderers, was chosen by Charles Liddell, engineer of the Taff Vale extension. Most of the piers are founded on rock, but two of the highest are on masonry built up from hard gravel, some 14ft below ground level.

The iron castings, of which there were 1196 tons in the piers, were made at Kennard's works at Falkirk, Scotland, and the machining and fitting was done at the site of the bridge. There are over 880 tons of wrought iron in the girders and bracings. This wrought iron, having an ultimate tensile breaking stress of between 29 and 30 tons per square inch, came from the Blaenavon Iron Company. The girders were fabricated in the Crumlin Viaduct Works, specially constructed near the site and engaged subsequently in making girder bridges for Italy, Spain, Portugal, and India.

The girders for Crumlin Viaduct were assembled on the ground and lifted singly—a " lift " of 25 tons including stiffening gear—by rope and tackle, at the centre of the piers and subsequently traversed sideways and lowered on to their bearings. The length/width ratio of the compression chord of one of the girders was 200 ; and although the first girder was successfully lifted to the top of the piers on December 3, 1854, and remained in position without lateral support for several days, the second girder collapsed whilst being hoisted and caused the death of a man riding it. Subsequently banjo bracing was applied to the top chords to stiffen the girders during erection. Twenty men were employed in lifting the girders ; it occupied them all one day to lift a girder in the highest part of the viaduct and it was usually set or finally fixed the same night, the men's time costing about £5. The last girder was erected on December 17, 1855.

Each pair of girders was braced laterally in the planes of the top and bottom chords and a decking 26ft wide of 6in Baltic timbers laid across the tops of the girders carried the two 4ft 8½in gauge tracks. The viaduct was tested on



Crumlin viaduct, which is about 4½ miles west of Pontypool, is in two parts, one of seven spans and one of three spans, all spans being 150ft in length. The viaduct was opened on Whit Monday, 1857, " amid great rejoicing "

May 7, 1857, when a maximum central deflection of 1¼in was recorded under a span loaded with trains on each track totalling some 380 tons. The official opening took place on Whit Monday, June 1, 1857, when, according to an eye-witness's account, " twenty thousand persons were present throughout the day, and cannon were placed on both sides of the valley from which volleys were fired with but slight intermission throughout the day, and caused the mountains to reverberate with their thunder." The viaduct, railway station and the trains themselves were gaily decorated with bunting and evergreens.

The timber decking was replaced by cross girders, rail bearers and a plate floor in 1868, when also some strengthening of the inner girders was carried out. In 1928 the decking was again renewed and in the following year the line across the viaduct was altered to a single cross-sleeper ballasted track in the middle of the spans. Apart from these and other minor repairs, the Crumlin Viaduct remains to-day much as it was a century ago. Passage of some of the heavier classes of locomotive is prohibited and the maximum speed of trains is limited to 8 m.p.h. The bridge continues, however, to carry the passengers and mineral traffic of a busy and important railway line.

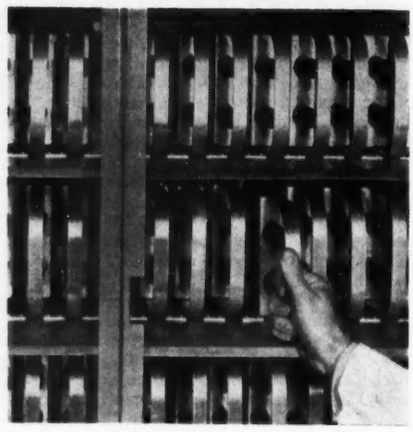


Fig. 3—Plug-in computing units in a typical cabinet of the " 405 " data-processing system

Electronic Data-Processing System

A COMPREHENSIVE data-processing system, consisting of an electronic computer with magnetic film storage and punched paper tape input and output equipments, has recently been installed in the City Hall, Norwich. The first operation for which the computer is to be used is the preparation of rate demand notes and the maintenance of ratepayers' personal accounts. The equipment is the National-Elliott " 405 " electronic data-processing system which is made by Elliott Brothers (London), Ltd., Century Works, London, S.E.13, and is marketed in the United Kingdom by the National Cash Register Company, Ltd. It is the first commercial installation of the National-Elliott " 405 " system.

Briefly, each " 405 " computer (Fig. 1) consists of a system centre, which is essentially a combined arithmetic and control unit, plus a range of input, output and storage units which are chosen according to the precise work the system is required to do. The system centre contains a number of rapid-access stores or registers, and a main working store. The rapid-access stores are magnetostrictive nickel lines, and the main working store is a rotating magnetic drum or disc according to the capacity required : in the Norwich installation it is a drum. These stores are in constant use throughout a calculation, and all information, whether from input or from the other (long-term) stores, is first transferred to them before it can be subjected to the actual data-processing operations.

For long-term storage in the Norwich installation, two magnetic film units (Fig. 2) are provided so that revised versions of records may be produced without alteration to the original. Films are available in reels of 1000ft, each capable of storing approximately 300,000 computer " words " (each word being equivalent to a nine-digit number, or six alphabetic characters), arranged in blocks of sixty-four for transfer from and to the system centre. Input and output are both by means of punched paper tape similar to that used in teleprinter installations. Input tape is punched by means of manual perforators, checked by manual verifiers, and " read in " to the computer at an average speed of 150 characters per second. Output tape is punched by the machine at some twenty-five characters per second, and is then transcribed into typed statements at an average speed of fourteen characters per second.

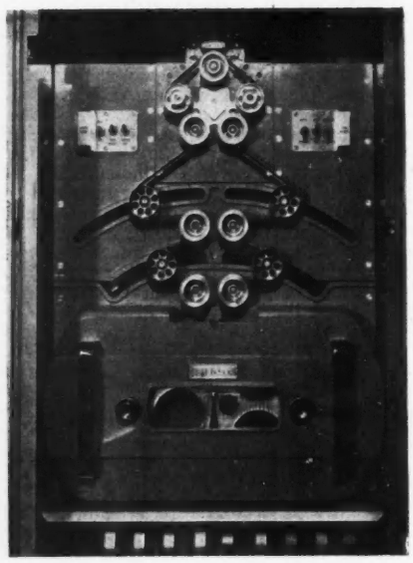


Fig. 2—Magnetic film storage unit of " 405 " data-processing system. There are two such units, each capable of storing 300,000 " words "

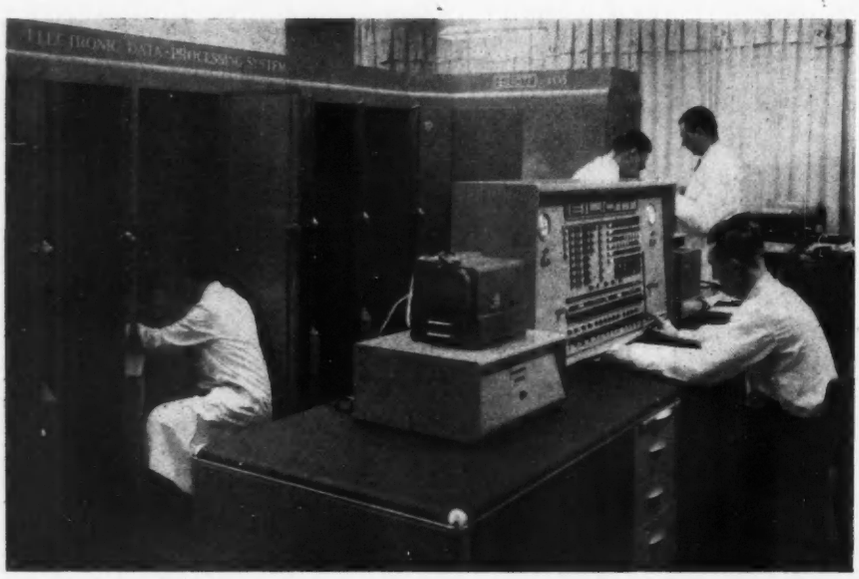


Fig. 1—Electronic data-processing system during installation in the Norwich City treasurer's department

The " 405 " computer at Norwich is housed in nine cabinets (Fig. 1), each about 7ft high, 2ft wide and 2ft deep. Two of these cabinets are at right-angles to the others, and the space between them is used for a corner cabinet containing test gear. The control console, input tape reader, and output tape punch stand on a nearby desk, while electric typewriters and hand perforators and verifiers are accommodated separately.

Like other Elliott computers, all " 405s " are built on a plug-in unit basis (Fig. 3). A special system of daily preventive maintenance enables any unit which is likely to fail within a certain period to be located in advance and replaced. The unit is then serviced at leisure, tested and returned to store as a spare.

The magnetic drum, which is the working store, has a capacity of 4096 computer words. When more capacity is required, a magnetic disc store with a capacity of either 16,384 or 32,768 words can be provided. The capacity of the high-speed store (nickel lines) in the system centre, which is 320 words in the Norwich system, can also be increased, if necessary, to 512 words. Additional film units can be added up to a maximum of sixteen, and film may also be used as an output medium to operate printing devices. Very much higher output speeds are then possible, one particular arrangement allowing up to 1000 characters per second. Other input methods are also possible, including a punched-card reader, which is capable of reading up to 600 standard, eighty-column cards per minute.

The " 405 " equipment operates basically with binary arithmetic, a system requiring only the digits 1 and 0. This method requires that the denary or sterling scales must be handled as part of the technique of " programming " the computer. Facilities are available, however, which allow the machine to work automatically in denary or sterling scales, with consequential reduction in the programming time required.

For the preparation of rate demand notes and the maintenance of ratepayers' personal accounts, details of all properties have been stored on reels of magnetic film, each of which holds 1000ft of film and records details of approximately 9000 properties. Excluding properties owned by the council, there are about 30,000 properties, divided into seven districts, to be processed. Two sets of films have been prepared. In the first set are seven films, one for each district, containing details of all properties. The second set is restricted to properties for which a person other than the occupier is liable for the rates, and consists of two films. The properties included in this set are grouped according to the identity of the owner or other person liable ; a special reference is stored with the record of property in the first set if it is also included in the second set.

The information stored on these films has been recorded on them by the computer, acting on information received from hand-punched paper tape. The preparation of this paper tape by means of keyboard hand perforators and verifiers

represented the largest task to be undertaken in preparation for the installation of the computer.

The magnitude of the task was increased by the large volume of recent amendments, including the recent revaluation of shop properties.

The preparation of rate demand notes is preceded by the punching on paper tape of the amount of the rate in the pound to be levied : this short length of tape is used to inform the computer of the current rate factor. Each reel of magnetic film is then placed on the computer in turn, the rate due calculated and a record, in punched paper tape form, produced containing all the details required for the printing of a rate demand note. This paper tape is used to control electric typewriters which produce the finished product on continuous stationery. In those cases in which a person other than the occupier is responsible for the rates, separate schedules of the properties are produced to be attached to the rate demand notes which will then show only the total amount due.

During the preparation of demand notes, the amount due from each ratepayer is stored on the magnetic film and a separate operation is carried out to produce a tabulation to form a ratebook.

The operations described above have been, or are about to be, completed for the financial year commencing April 1, 1957. During the course of the financial year, the magnetic films will be processed each week to record details of cash paid by ratepayers and amendments necessitated by, for example, changes of occupier and sales of property by owners. Details of cash payments and amendments will be punched into paper tape each week and fed to the computer. This information will be sorted into reference number order (to coincide with the order in which properties are stored on the film) and subsequently recorded thereon. This operation will include the calculation of void allowances and preparation of demand notes for rates due for part of the half year following changes of occupation or reassessment. To give a concise visible record, tabulations showing all the information stored on the magnetic films will be produced at the end of the half year During this process a new set of films will be produced recording only the information required to start a new half-yearly cycle of operations.

Next year, the computer will take over sundry debtors records for some 50,000 accounts, the integration of water rate billing and accounting with that of the general rate, analysis of invoices and certain aspects of personnel records. Future plans include costing, payroll, and maintenance of accounts with loan creditors, including half-yearly payment of interest and instalments of principal.

Eventually, when the computer is being used to capacity, staff savings in the order of 20 per cent can be expected.

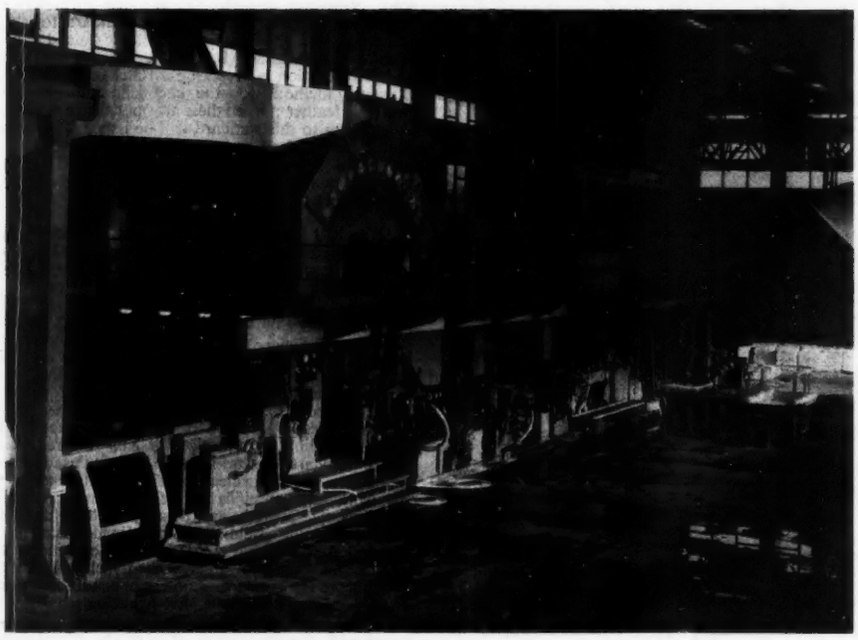
Cellulose Wadding Mill at Aylesford

SINCE the discovery of papermaking the uses of paper have become manifold and the craft and also the methods of production have been modified and developed to meet expanding requirements. The invention of a machine to make paper helped to increase production, while the introduction of ground wood pulp as a substitute for rags solved the problem of the raw material supply. In more recent years chemistry has played an increasingly important part in the papermaking industry, and it was through this way that cellulose wadding was developed. It was introduced in 1915 as a substitute for cotton wool, and since that time further uses for cellulose wadding have been constantly found and new products devised for use in industry and commerce.

One form of the material was introduced to Great Britain in 1926 and imported from one of the Kimberley-Clark Corporation's mills in Canada until the second world war. Since 1952, however, the material has been manufactured in this country in partnership with the Reed Paper Group and a factory established at Aylesford for making the various products. A rapidly expanding demand, reinforced by the expansion of the field of application, demonstrated that to satisfy requirements a new wadding mill was required and plans to that effect were formulated in 1954. A basic requirement was the incorporation of pulp preparation, wadding manufacture, reeling and slitting in one building with the provision of mechanical conveyance of material to the conversion plant. The scheme to build up production capacity has culminated in the construction of a new integrated plant for the manufacture of wadding, of which the principal item is the high-speed wadding machine. The new mill is owned by Kimberly-Clark, Ltd., a company owned by the Kimberly-Clark Corporation of America, in association with the Reed Paper Group and, as recorded on page 669 of our issue of May 3, was opened on April 30 by the Duke of Edinburgh, who toured the mill as well as the conversion factory.

The wadding machine, of which we reproduce a general view, by reason of the hygienic nature of the product, is almost totally enclosed with chests and pits tile lined throughout and fitted with a high degree of instrumentation, which, rather unusually, has been incorporated in the framing of the machine. Jointly designed by the combined resources of the companies concerned, together with Bertrams, Ltd., who built it, the machine has a length of about 120ft and a potential running speed of 3000ft per minute. This high speed has been made possible by the introduction of innovations and improvements in mechanical operation and control, coupled with a high degree of automation. Another factor in producing a high running speed is the electronically controlled drive made by the British Thomson-Houston Company, Ltd., there being no reduction gearing between motors and rolls. The design of the fourdrinier section of the machine permits the rapid removal and replacement of the wire, while the overall design ensures the economical use of water. Of particular interest are the pressure inlet system of Kimberly-Clark design feeding the wire, and the high-pressure drying cylinder combined with a high-velocity hood, which play an essential part in maintaining the high speed. With regard to the preparation plant and auxiliary equipment the inclusion of modern handling methods provides for complete continuity of operation from the intake of wood pulp to the preparation plant to the production of the crepe wadding.

The building housing the wadding machine and auxiliary equipment measures 250ft by 100ft by 50ft overall internal height and has a reinforced concrete frame with a cavity brick in-fill. Steel trusses support the steel cavity roof decking and the floors are of reinforced concrete except in way of the wadding machine substructure, which is of steel. There are two main floors, the auxiliaries being located on the ground and the machine itself on the first floor, and a gallery running the full length of the building on each side. Approximately 75 per cent of the wall area consists of double glazing, which assists in insulating the building. Also affording both thermal and sound insulation is the Burgess acoustic suspended steel ceiling fitted to the underside of the steel trusses. Smooth clean internal finishes are provided by the extensive use of tiling both for floor and walls and the painting of exposed concrete surfaces. The hygienic nature of the product calls for the exclusion of dust, and for this purpose the air inside the mill is at a pressure slightly in excess of that of the outside air. The heating and ventilation control plant has been installed by Carrier-Ross, Ltd., together with an air conditioning system.



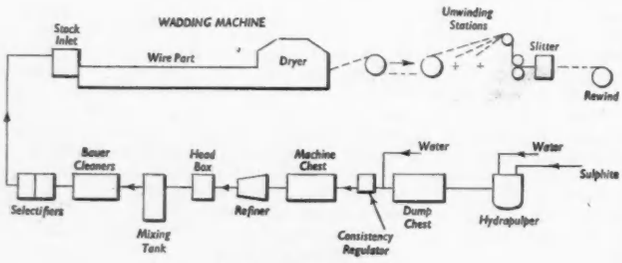
Dryer and hood of cellulose wadding machine. The stock inlet end is on the right

Preparation Plant and Cellulose Wadding Machine

The raw material is delivered by road and rail transport and unloaded by a gantry crane into an air lock compartment and from thence on to the mill floor by fork lift truck where there is sufficient storage space to take more than a day's supply for two machines. Our line diagram shows the production flow through the mill and the first stage is the pulping of the sulphite, which is carried out in a " hydrapulper," which is a bowl-shaped vessel, 14ft in diameter, having an impeller at the bottom driven through a Wellman Bibby coupling and a gearbox by a 200 h.p. electric motor. Water is metered into the " hydrapulper " before a weighed quantity of sulphite is fed into it by means of a slat conveyor sited at floor level. An interlocking device prevents the operation of the conveyor so that no raw material is dumped into the " hydrapulper " before the water is admitted, thus avoiding the possibility of damage. Vanes on the impeller and on the sides of the " hydrapulper " break up the wood pulp, a process which requires approximately thirty minutes, according to the quality of the raw material supplied. When starting up the process fresh water is used, but subsequently white water is utilised. When the sulphite has been broken up the contents of the " hydrapulper" are pumped to a dump chest, which has a capacity sufficient to take a number of batches of prepared rough stock. The dump chest, which is of concrete and is tiled inside and out with

hollow block tiles tied together, has semicircular ends at one end of which is an impeller for keeping the stock circulating and thoroughly mixed.

Stock from the dump chest is pumped to the machine chest, which is similar to the former, and samples are taken from the pipeline and passed to a consistency regulator, which, when required, causes water, generally white water, to be added to the stock. Another pump forwards the rough stock from the machine chest to the two "hydrafiners," which can be used in parallel, in series or singly, as required, and



Wadding mill flow line

before reaching which, another consistency test is taken and adjustments made. They are of double cone design and ribs on the plug and the shell, by means of a brushing action, further refines the stock as it passes through the annular space between the plug and the shell. From the refiners the fine stock passes to a head box fitted with a stuff gate control valve, which is finely adjusted so that only the exact quantity of stock is allowed to go forward to a mixing tank, where the consistency is considerably reduced. From the latter the refined stock is pumped through a battery of two-stage Bauer cleaners, supplied by Vickery's, Ltd. In these centrifugal separators sand and any other foreign matter sinks to the bottom of a cone-shaped chamber and is ejected while the accepted stock rises and goes forward to a tiled compartment. A "Fan" pump pumps the stock from this compartment through two "selectifier" screens to the stock inlet, which incorporates a pressure box of Kimberly-Clark design, feeding the wire. The "selectifiers" consist of an outer compartment containing a perforated screen basket, inside which rotate three aerofoil-shaped arms which serve to prevent any foreign matter passing outwards through the screen and on to the stock inlet. The foreign matter collects in the bottom of the basket and is passed downwards to a trash receiver. The preparation plant and all machine pumps have been provided by Black-Clawson International, Ltd.

The pressure inlet feeds the stock at the required volume on to an endless woven wire screen stretched over rolls. The portion of the wire on which the sheet is formed is supported by intermediate rolls and open boxes connected to a vacuum pump, all of which assist in draining water away. The sheet is sufficiently coherent to be transferred to a felt at the lick-up couch. This consists of a suction couch roll round which the wire returns and a rubber-covered top couch roll, passing around which is an endless wetted lick-up felt, which picks the sheet up on its underside. The felt with the sheet underneath passes through a press consisting of a rubber-covered plain upper roll and a rubber-covered suction lower roll, over which passes another felt. Thus the sheet, from which most of the water was removed at the wire, is squeezed between two felts when passing through the nip of the press and further moisture is removed. The upper felt with the sheet still adhering to the underside passes round a pressure roll which is in contact with a 12ft diameter cast iron drying cylinder. The sheet is transferred to the dryer which is heated by steam at 125 lb per square inch. The pressure at the press and pressure roll is controlled by means of air diaphragms. The sheet is in contact with the dryer over an arc of about 300 deg. and is then creped off by a doctor and passes round a reel drum. In contact with the drum is a core shaft on which the finished sheet is reeled up.

Over the dryer is fitted a high-velocity hood system, supplied by the Carrier-Ross Engineering Company, Ltd., in which heated air is supplied to transverse ducts from which jets of air at high velocity are directed on to the sheet. Combined with the supply system is an exhaust system, all being totally enclosed with the hood.

The felts are provided with stretch equipment to maintain the correct degree of tension and there is a special roll guide adjustment to ensure that the felt runs true, similar equipment being fitted to the wire.

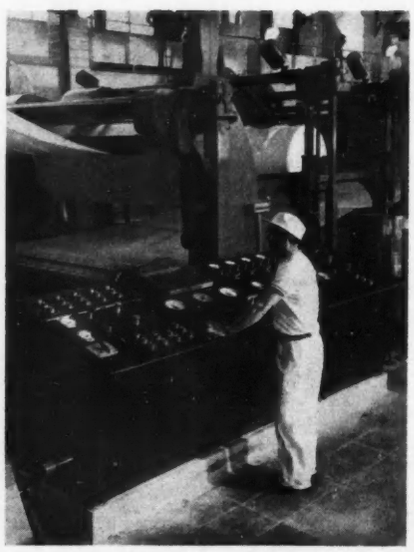
When the reel of finished sheet has reached the required yardage it is automatically ejected and a new core shaft introduced. The full reel is retracted by two arms and the new core shaft is elevated into position by transfer arms and simultaneously an air jet across the width of the sheet breaks it and at the same time presses it on to the new shaft so that reeling-up continues without interruption. The full rolls pass along rails and over a built-in weighing machine. At this point samples are taken and examined for quality and should the weight not be correct then an appropriate modification is made to the setting of the stuff gate control valve together with the adjustment of other variables which affect the quality of production.

An automatically-controlled crane having twin hooks picks up the full reel and transfers it to the unwinding station, part of which can be seen in our illustration together with the control panel. The winder, which has been supplied by the Constructional Division of Brookgate Industries, Ltd. (a member of the Reed Group), is equipped with a number of unwind stations which permit sheets of a varying number of ply to be reeled up. Here the reels are unwound over a folding board and the sheet passed through a number of plain presses and an embossing press and then to the slitters and the rewind.

Afterwards the reel is transferred by a monorail conveyor to the converting factory or by lift to store. A high degree of instrument regulated automation is applied to the machine and throughout the whole sequence of operations, and the instrumentation has been supplied by Taylor-Short and Mason, Ltd.

To deal with broke sheet there is a broke "hydrapulper" and an associated dump chest. The consistency of this broke stock is regulated and after treatment the stock is transferred in controlled quantities to the main "hydrapulper" dump chest.

A Bowser lubrication system, provided by Liquid Systems, Ltd., is fitted, there being one system for the dryer bearings, in which the lubricating oil also acts as a coolant, and one for all the other roll bearings. W. C. Holmes, Ltd., supplied the two Connersville pattern vacuum pumps, each of which can deal with 3200 cubic feet of air per minute at a vacuum of 15in of mercury. The general compressed air system is supplied with air at 85 lb per square inch by two Reavell quadruplex compressors, one being a standby, while a Williams and James compressor in association with an electrodryer provides air at 100 lb per square inch to the instrument air system. All pipelines carrying stock and white water are of stainless steel and all electric motors above 25 h.p. for the auxiliary plant were made by Mather and Platt, Ltd., while smaller motors were by Crompton Parkinson Ltd.



Control panel of wadding winding machine

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

ELECTROPLATED COATINGS OF SILVER FOR ENGINEERING PURPOSES

No. 2816 : 1957. Price 4s. This is the latest addition to the series of standards dealing with electroplated coatings of various metals and is concerned with articles used for engineering purposes. Among the requirements in the specification are those for pre-treatment of the articles to be plated, lead content of the silver deposit and finish and appearance of the electroplated article. It does not deal with the electro-forming of silver. Tables specify minimum thicknesses for silver on copper and copper alloys, ferrous metals, and aluminium alloys.

To facilitate the electroplater's interpretation of his client's instructions, an appendix, "Information to be supplied by the purchaser to the electroplater," has been included. The information to be provided is dealt with under four heads : surfaces to be plated ; thickness ; additional protection ; composition of basis metal. Each method of test is specified in a separate appendix and includes the determination of lead in silver ; the determination of local thickness ; and adhesion tests. Notes on silver plating are provided as a guide to normal shop practices and to indicate to the designer or purchaser the limitations of the plating process.

VEGETABLE-TANNED LEATHER BELTING

No. 424 : 1957. Price 4s. This revision of B.S. 424 is the result of a review of the 1931 edition in relation to the quality of hides now available. The principal differences between this and the earlier edition are : strips must now be cut at a maximum distance from the backbone ; hides have to be rounded into butts before tanning ; new requirements are specified regarding the number and position of "open" and "blind" warbles ; and splices are specified on a substance basis, rather than on width. They are no longer required to be stitched, since stitching is now considered to weaken rather than to strengthen the join. Wherever possible, the chemical methods of test make reference to the British Standard for the sampling and analysis of vegetable-tanned and chrome-tanned leather (B.S. 1309).

The Institution is preparing a fuller set of British Standard methods for the chemical and physical testing of leather ; when these are published a suitable amendment to this standard will be issued. Among the marks required to appear on the belting is the number of this standard, i.e. "B.S. 424." There is also a recommendation that the direction of running and the pulley side of the belt be indicated.

GENERAL REQUIREMENTS FOR THE GAS WELDING OF WROUGHT ALUMINIUM AND ALUMINIUM ALLOYS

No. 1126 : 1957. Price 3s. Considerable progress in welding techniques has been made since the first publication of this British Standard in 1943. This revision—in which details of weld preparation have been specified for the first time—reflects the best of that experience. The clause on filler rods now includes a table which relates to various grades of parent metal to recommended filler rods. Another new feature is a section devoted to "Information Required by the Welding Organisation." This requires that drawings, charts or working schedules for use by the welder should contain clear technical details regarding the work—e.g. specification of the parent metal ; locations, sizes, lengths and details of all welds and treatment after welding. Since inadequate flux removal may cause a weld to corrode, details of satisfactory flux removal have been included as an appendix to the standard. Another appendix contains concise recommendations for working the weld metal. The standard, which is illustrated, was prepared with the full co-operation of the Aluminium Development Association.

Gamma Radiation Laboratory for Lubricants

A PROGRAMME for studying the effect of nuclear radiations on various lubricants was started in February, 1953, at the Shell Thornton Research Centre, in collaboration with the Atomic Energy Research Establishment at Harwell. Since the start of this programme a radiation laboratory has been built at the Centre and a Cobalt 60 source, for intense gamma radiation has been installed.

The Cobalt 60 is in the form of pellets and six of these pellets are sealed in an aluminium capsule contained in a stainless steel cylinder 3in long and ¼in diameter with walls 0·032in thick, as shown in Fig. 1. This cylinder is attached to a flexible steel cable, which moves the source within a 1in diameter stainless steel tube. Because of the intense gamma radiation from the source, it is necessary to provide concrete shielding round it with a minimum thickness of about 5ft. The shielding is constructed of concrete blocks, staggered during the building so that there is no direct path for the radiation along the joints. This arrangement is illustrated in Fig. 2, which shows the building under construction. During experiments the source is in the exposed position at the end of the tube in the cell. Before anyone can enter the cell the source must be withdrawn up the tube until it lies within the loop in a specially dense mass of concrete. The system is equipped with an elaborate safety interlock system whereby the key which unlocks the door of the radiation cell is also that which unlocks the operating mechanism (located in the control room) for the withdrawal or exposure of the source. The key can only be removed when the source is safely retracted. Similarly, the key cannot be taken from the door to operate the source mechanism unless the door is first securely closed and locked. Finally, the operator uses a sensitive Geiger counter in front of him at arm's length as he walks through the labyrinth to the cell.

Samples to be irradiated are arranged around the source in specially-shaped containers designed to make the maximum use of the radiation available, as shown in Fig. 3. Gamma-rays, unlike neutrons, do not modify the nuclei of atoms they encounter so that no radioactivity is induced within the cell. It is, therefore, perfectly safe to enter the cell and examine the samples once the source has been withdrawn within the dense concrete block. The samples may be viewed during irradiation by an optical system involving a mirror and spotlight. All the usual services—water, electricity, gas, compressed air and vacuum, are provided in the cell so that various experiments can be carried out under the influence of gamma radiation.

The Cobalt 60 source emits gamma-rays only, but some mechanisms of a nuclear power plant will be exposed to neutrons as well as to gamma-rays. In the experiments done in collaboration with Harwell the samples were inserted into a nuclear reactor, where they were subjected for various periods to a neutron flux of about 10^{12} thermal neutrons per square centimetre per second, together with the associated fast neutrons and gamma radiation.

Under the influence of radiation, molecules can absorb large amounts of energy. As a result the molecules become, in chemical terms, "excited," and, depending upon their structure, can break down into highly reactive fragments. These fragments can then combine with neighbouring molecules to form compounds of higher molecular weight, as evidenced by significant increases in viscosity of the irradiated material. At the same time these changes are accompanied by the evolution of gases such as hydrogen and methane. Many materials, including a variety of synthetic as well as petroleum lubricants, have now been exposed to various dosages both of gamma radiation and neutrons.

An examination of the samples after irradiation showed that many had undergone profound changes in molecular structure and physical properties. For example, certain conventional

Fig. 2—Labyrinthine walls of radiation laboratory under construction at Thornton Research Centre. The joints between the concrete blocks are staggered

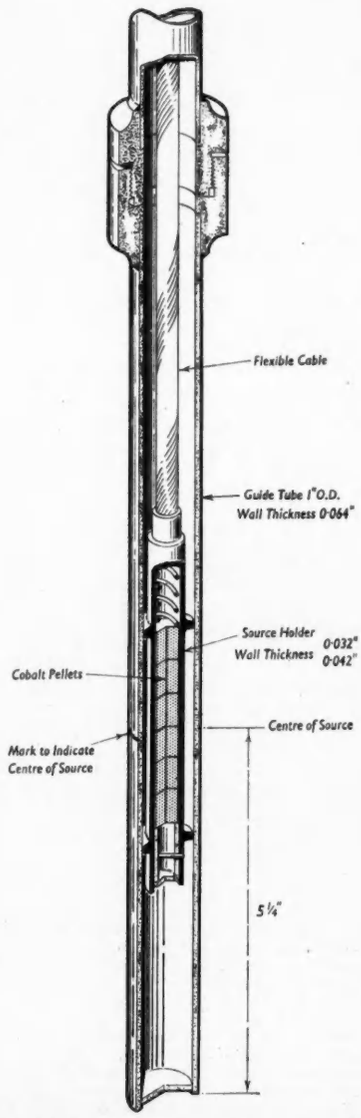


Fig. 1—Sectioned view of radioactive cobalt source in operating position

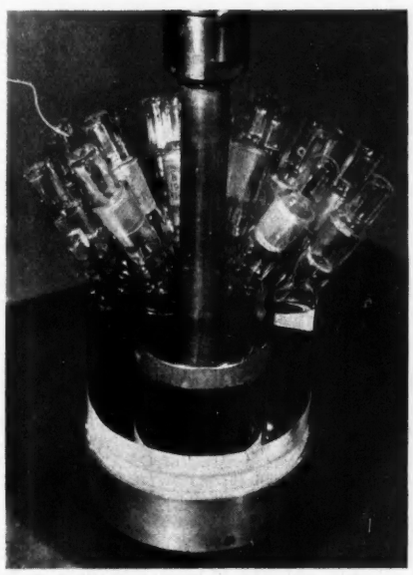


Fig. 3—Maximum use of the cobalt 60 source is obtained by irradiating the specimens in shaped containers as shown here

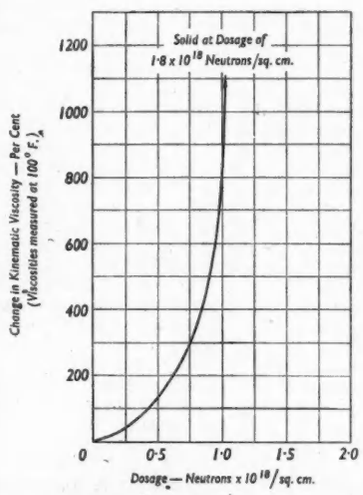


Fig. 4—The effect of irradiation on a conventional lubricant

petroleum lubricants rapidly darkened in colour and increased in viscosity with increasing dosage of irradiation. They eventually became transformed into jelly-like masses with melting points in excess of 220 deg. Cent. and largely insoluble in petroleum spirit, cyclo-hexane, benzene, acetone ethanol and ether. Similar effects were observed with some synthetic diesters and silicones. Fig. 4 shows the effects of irradiation on a conventional lubricant.

This research work at Thornton has been planned to obtain information on the influence of molecular constitution of stability towards atomic radiations and already lubricants have been developed which show practically no change in physical properties at radiation dosages which transform many lubricants into solids.

In addition to resistance to radiation, other properties are required in the lubricants for equipment of nuclear power stations. For example, because contamination of the reactor would be intolerable, any lubricants which might come in contact with the coolant gas of the reactors must have an extremely low vapour pressure. Also the lubricants must, in some cases, be able to withstand high temperatures for long periods, since it may be possible to renew the lubricants only at intervals of several years. With the gas-cooled reactor there is also the problem of compatibility of the lubricant with hot coolant, e.g. carbon dioxide under high pressure.

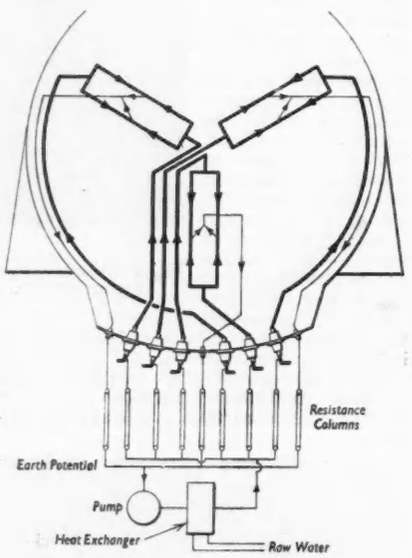
As a result of research work in which the Cobalt 60 source has played its part, The Shell Petroleum Company, Ltd., has developed a number of special lubricants which are resistant to radiation and which meet the requirements of the nuclear power stations now being built for the C.E.A. These lubricants, which will be supplied as Shell Atomic Power Lubricants (APL), will be used in the Bradwell station of the C.E.A. Further research is in hand to develop lubricants still more resistant to radiation which will be required in future for more advanced designs of nuclear power plant.

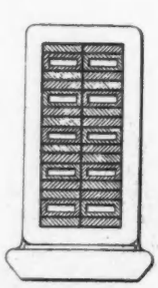
Direct-Water-Cooled Stator Windings for Large Alternators

IN preparing designs for alternators of about 200MW rating and upwards the General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2, is providing for direct water cooling of the stators. This method of cooling makes possible a reduction in the size of stator slots and core plates and is one means of reducing the stator weight to keep it within the present transport limits of 150 to 160 tons. The purpose of the G.E.C. design is to produce an efficient cooling arrangement with the minimum modification to established practice in the manufacture of alternator stators. Water is used as the coolant because its high thermal capacity and low viscosity favour the use of small ducts with a flow through several conductors in series, thus reducing to a minimum the number of tapping points on the winding. In the stator, therefore, there is nothing unusual about the method of insulation, the leakage surfaces are normal, and all pipework is metallic, with brazed joints. The temperature rise of the water and copper can be predetermined accurately.

The design of the water circuit is based on the philosophy that the ideal direct cooling arrangement (from the point of view of least disturbance to the insulation) is one in which the coolant path is totally contained within the normal insulation of the windings with the supply and discharge points at earth potential. Thus the circulation would be from the neutral point, through half the conductors of one phase to the line terminal and back through the remainder of the phase conductor to the neutral point. The pressure drop through such a coolant path would, however, be high and, since it is desirable to limit the maximum water pressure to a value below that of the hydrogen in the casing, the number of conductors in series must be reduced, with additional tapping points to the windings to provide lower resistance paths for water flow.

The G.E.C. arrangement is illustrated diagrammatically in here, the stator windings being represented by the thick lines, with each phase divided electrically into two parallel circuits—an essential provision in units of the size under consideration. The water flow is into both ends of each phase winding, with discharges at the centre point of each half phase, thereby giving twelve coolant circuits in parallel through the stator. The terminal bushings have hollow stems through which the water passes into the casing: the efficient cooling of the bushing by cold water greatly increases its current-carrying capacity and eliminates the possibility of any expansion strains. Three small bushings are also required for the warm water discharging from the windings, the connection between them and the mid-points of each phase being made with metal pipes insulated and supported in a similar manner to the electrical leads. To break down the voltage between the bushings and the earthed water-circulating pump and heat exchanger, resistance columns are provided at any convenient position in the foundation block. They are very simple and consist of straight tubes of insulation material of the appropriate length and diameter to contain a column of water of the required electrical resistance.





Diagrammatic arrangement of G.E.C. water-cooled stator winding and (below) section through water-cooled stator conductor

The G.E.C. water-cooled stator conductor, shown above, consists of a number of thin-walled copper tubes of reasonable depth spaced symmetrically within the conductor, each tube being associated with two solid copper strips placed above and below it with only light insulation interposed. The water circulates through all tubes in parallel, the quantity through each being designed to absorb the loss both in the tube itself and in the associated strips. Since the heat is transferred from the strips to the tube over a wide area, the temperature gradient across the insulation is negligible and all the copper in the conductor at any section is at substantially the same temperature.

This arrangement gives considerable freedom in the selection of the best proportions for the various components from the point of view of losses, hydraulic efficiency and ease of handling. For example, if a few tubes were arranged to provide the same total duct section, the depth of each tube and the wall thickness would become too great having regard to eddy current losses. With a larger number of tubes of more suitable wall thickness the water duct cross section would become long and narrow, the pressure drop across a given length would be appreciably higher and an increase in the number of tapping points to the windings would be necessary. The combination of tubes and strips, however, allows the greater part of the current to be carried by the most effective conductors, namely, insulated thin laminations, and the water to flow in a few channels of reasonably good shape with a low pressure drop, the walls of the tubes also being used to carry current.

As is usual with all except very small alternators, the winding cross section is subdivided to reduce the eddy current losses, the conductor consisting of a number of horizontal strips which are individually insulated and transposed. The method of transposition used by the G.E.C. is such that each strip is cyclically transferred from one position in the slot to an adjacent position when making the joints between conductors in the stator overhang, the interstrip insulation being continuous throughout the winding. This arrangement involves very simple interstrip insulation, uniform depth of copper and a high space factor in the slot with good equalisation of induced stray voltages in the stator overhang. The same principle will be used for the direct-cooled winding but the design will be slightly modified to eliminate the need for "jumpers" normally used to transfer the required number of strips from the top to the bottom of the stack of laminations when making the brazed joints to the next coil. At both ends of the stator the strips and tubes follow round from top to bottom in a regular sequence.

Generally, therefore, the insulation of the windings is the same as that used by the G.E.C. on alternators for many years. At only six points where the warm water discharge pipes leave the windings is the appearance different from that of a stator with conventional cooling, but here again a standard insulation technique is employed, the taping being continuous down to the bushings as on the main electrical leads.

For various reasons the increase in output from a single large set has not been accompanied by a corresponding increase in the machine voltage and therefore the stator current will be appreciably higher; for example, it is of the order of 10,000A for a 300MW alternator. With the greatly increased current carrying capacity of the water-cooled bushings there should be no difficulty in handling even greater ratings.

To gain operational experience with this method of direct water cooling it is being incorporated in a 60MW alternator. Nevertheless, the G.E.C. view is that the additional complications introduced by liquid cooling are only justified where the weight of the stator becomes the limiting factor and this does not occur until outputs exceed about 200MW.

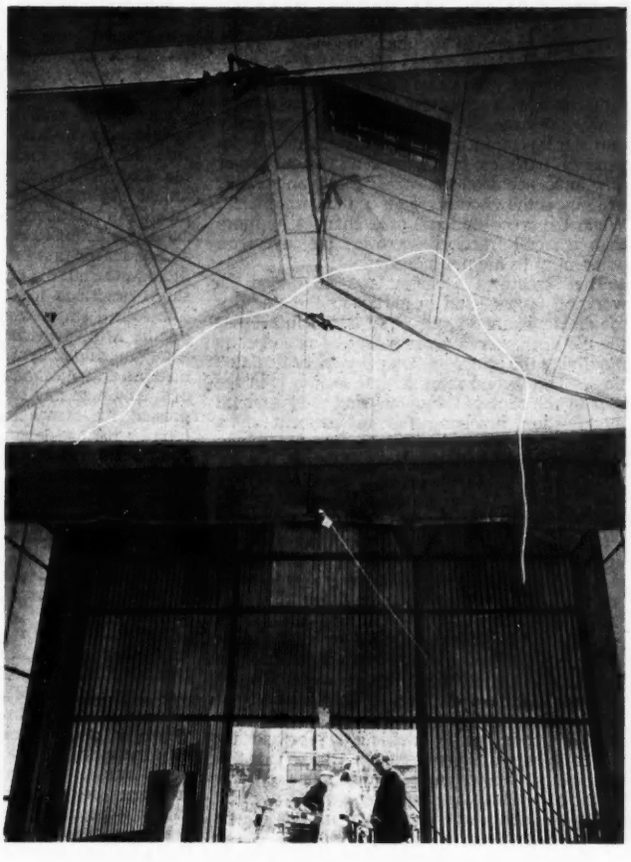
MAGNETIC SEPARATION.—An improved efficiency in the extraction of fine iron and feebly magnetic oxides from powder, granular and liquid materials is claimed by Electromagnets, Ltd., Bond Street, Birmingham, 19, for the "Boxmag" filter. The magnetic circuit includes a steel grid, the material treated passing through the grid and the ferrous content being held on the edges. The accumulated contaminant is removed by turning off the magnetising current, when a flap valve automatically diverts the flow to another outlet, and energising the vibrator, if the latter is not in use during separation due to the freely flowing nature of the charge.

Industrial Fire Control

To demonstrate a method suggested for the restriction of fires, a building representing three bays of a factory has been constructed, there being two bays having walls and ceiling insulated, a division erected consisting of a fire curtain with a fire stop above and heat and smoke exhaust ventilators fitted in the roof. Fusible links operate curtain and ventilators and an experimental fire was staged recently to indicate the degree of effectiveness of the system.

CONSIDERATION of the many factors related to the rapid spread of industrial fires, and the subsequent extensive damage to property resulting in incalculable indirect losses in production, has emphasised the urgent need for an effective method of fire control. Analysis of fires has shown that the rapid consumption of air results in incomplete combustion which gives rise to dense smoke and concentrations of carbon monoxide. The latter are explosive and the inability of smoke and superheated air to escape through the roof not only raises the ambient temperature, and so hampers fire fighting, but causes the fire to spread horizontally. The superheated air, apart from being lethal, has explosive force and rapidly dries out combustible material, so that it ignites like tinder and causes liquids to become volatile.

Better methods of construction may help to prevent the outbreak of fire, but to control such an outbreak, fire breaks and suitable ventilation have been proposed. A plan involving a number of measures designed to restrict the spread of fire has been evolved by Cape Building Products, Ltd., Cowley Bridge Works, Uxbridge, Middlesex, in collaboration with Colt Ventilation, Ltd., of Surbiton, Surrey, and a structure prepared for demonstration purposes. This building incorporates a fire break, an insulation system for walls, roof, stanchions and trusses and ventilation units. This structure was set on fire last week and the purpose of the experimental firing was to demonstrate that an outbreak of fire can be restricted by the use of an asbestos cloth fire curtain, "Asbestolux" fire stops and insulation lining to roof and walls, and "Colt" heat and smoke exhausts.



Inside of test building showing insulation, fire curtain, roof ventilator and fusible links

The experimental building, of which we illustrate the interior, is a tubular steel-framed erection measuring 30ft in length by 20ft wide by 20ft 6in in height to apex and divided into three bays, two of which form the fire compartment. Standard corrugated metal sheeting is applied to one side of the building, while the other is sheeted with "Galbestos" and "R.P.M." sheeting. "Asbestolux" sheets backed with "Rocksil" building mat and suspended in steel tee sections forms the insulation lining, while a similar lining is applied to the walls. The fire curtain is of woven blue asbestos fibre with a metal strand interweave, and is 20ft wide by about 14ft 6in high and incorporates escape flaps. Both weave and material have been chosen to withstand the maximum temperature likely to be attained and to ensure integrity for a specified number of hours. The bottom of the curtain is weighted with a chain and the sides have guide wires sewn in to ensure that the curtain is not sucked out of position. A hollow steel roller, supported on steel stanchion, carries the curtain and its fall is operated by a fusible link suitably placed. These links are set to fuse at approximately 150 deg. Fah. and the rate of fall of the curtain is controlled by a damping mechanism. The curtain support stanchions are insulated and a fire stop of "Asbestolux" sheets is fitted above the curtain to the apex of the roof. Three "Colt" dual-purpose heat and smoke exhausts are fitted, two being in the fire section, and are arranged to operate by fusible link or by hand.

The material to be ignited in the building consisted of 2 tons of timber, 20 gallons of kerosene and rubber tyres having a total calorific value of 42,000,000 B.Th.U. and sufficient to give a fire loading of 100,000 B.Th.U. per square foot. The ventilators have an area equal to 2 per cent of the floor area of the fire section of the building and enable superheated air to escape at a velocity in excess of 1500ft per minute. Under conditions obtaining it was estimated that the two "Colt" ventilators would exhaust 1,000,000 cubic feet of air during the period of the fire and in so doing would equalise the pressure and extract about 5,000,000 B.Th.U. of heat. In earlier tests at temperatures in excess of 1600 deg. Fah. the air in the building expanded by four times and created a pressure of 4 tons per square foot. Based on these results it was estimated that if there were no ventilators the pressure inside the building would be 6000 tons higher than the outside atmosphere. It is claimed that the fitting of the ventilators avoids the risk of explosion from internal pressure, removes smoke and a large amount of heat and so enables firemen to approach the fire more closely.

The experimental firing took place on Tuesday, May 28, at the works of Cape Building Products, Ltd., and was allowed to burn for a period of thirty minutes, during which thermocouple temperature readings were taken at intervals of five minutes at selected positions. The temperatures, in degrees Fahrenheit, are recorded in the following table :—

	Thermocouple positions				
	A	B	C	D	E
Start	88	105	85	85	86
After :					
5 minutes ...	1320	720	520	1840	840
10 minutes ...	2450	1130	810	2520	1590
15 minutes ...	2280	1650	1430	2300	1490
20 minutes ...	2070	1880	1570	2000	1220
25 minutes ...	1870	1470	1080	1800	1190
30 minutes ...	1730	1390	820	1650	1170

Positions of thermocouples :
A—At apex of fire compartment.
B—At steel structure above lining in apex of fire compartment.
C—At apex of protected compartment.
D—At tie beam level in fire compartment.
E—At tie beam level in protected compartment.

Comparison of the temperatures at A with those at C and of those at D with the temperatures at E indicates the measure of the protection afforded by this combination of fire stop, asbestos curtain and adequate ventilation to exhaust smoke and heat. After the fire had been extinguished it was possible to make a quick examination of the building. The insulation sheets were generally intact and no doubt in those that were cracked the damage was due mainly to the effect of the rapid cooling of the structure. The sheets appeared to be calcined to a depth of about half their thickness. To add realism to the test, storage racks were placed in both sections of the building and the wrappings of those in the protected section were intact after the test, although no doubt the temperature had affected the contents.

Research in Hydromechanics

THE British Hydromechanics Research Association, last week, held open days at its laboratory at Harlow, Essex. Visitors were able to see in action models on a small scale demonstrating the spill-ways of the Roseires dam on the Blue Nile, the formation of air vortices above the turbine intakes of the Kariba dam, and the transport of solids in hydraulic pipelines.

One full-scale experiment on view was a hydrostatic transmission, to handle 80 h.p., which is under development for the Motor Industry Research Association. In order that the differences between this transmission and such drives as the Sundstrand and the Badalini (page 113, January 18, 1957) can be discerned, it will be described in some detail. The engine drives a rotor, in the front and rear faces, respectively, of which are the nine cylinders of what may be called, conveniently if not invariably accurately, the pump and the motor. In these cylinders slide sleeves with spherical internal surfaces hold the ends of the hollow pistons : the other ends of the piston are carried, again on spherical seats, on a ring rotating with the rotor and running on a swash-plate. It will be understood that the cylinder bores are closed and oil enters and leaves through the hollow piston and ports in the swashplates. The two swashplates are, of course, at opposite ends of the unit : the motor swashplate is fixed in inclination and mounted upon the output shaft, the oil throughput passing through passages in the end cover of the unit. The pump swashplate is pivoted in the casing and supported on curved thrust faces through ports in which the oil passes to and from the pump. The pump and motor ends of the unit are connected by external piping and the contained space is kept full of oil under pressure by a separate pump. It can be seen that the pump throughput depends on swashplate angle and input speed, while the

motor throughput depends on the difference between input and output speeds ; thus, when the swashplate is set in the transverse plane, a direct drive is provided. The pump swashplate can be moved in either direction to an angle equal to the motor angle—since all cylinders are the same radius, these two extremes represent an infinite reduction (neutral) and an overdrive of 0·5. A further increase of angle in the appropriate direction would give a reverse gear, but the efficiencies in this condition were found to be unacceptably low.

Details of the construction of this unit are that journal and thrust bearings are all plain, with the exception of one single-row ball thrust race which sets the end float in the casing. The pistons are kept in contact with the swashplates by means of the rings carrying the outer ends of the pistons—valve plates in this design—which are forced apart by springs which are not cycled during running. A design with relatively complicated porting and pistons, and an external circuit was chosen because it was expected that efficiencies would not be high and that cooling of the oil in the circuit would be necessary. The result has been that viscous losses are quite important, arising particularly on the large fast-running valve plates, while if a low viscosity oil such as is used in hydraulic circuits is employed leakage losses become prominent. The experimental machine was kept under pressure on one side of the circuit only, so that the torque could not be reversed without causing cavitation, and was running at an input speed of about 1600 r.p.m. : it weighed about 80 lb. The nine-piston construction is claimed to give a very smooth output torque, but it was noticeable that the noise became obtrusive when the swashplate was moved away from the direct drive position.

Other researches of a mechanical engineering nature include testing seals and glands and an investigation of reciprocating seals, showing that the seal may be completely separated from the shaft by oil, in the manner of a piston ring. A study of the behaviour of automatic valves in pumps and of the behaviour of unbalanced disc valves were displayed. The theory of hydraulic lock at high pressures due to the instability of a piston in a tapered bore (THE ENGINEER, April 12, 1957) was expounded. The hydraulic experiments were in many cases presented with great clarity and force by the use of transparent plastics tubing.

Australian Aeronautical Research

THE report for the year ended June 30, 1956, of the Department of Supply Aeronautical Research Laboratories records a number of interesting applications of blowing into boundary layers. One method of suppressing separation consists of discharging air through a spanwise row of holes drilled in the aerofoil surface, each jet acting as a vortex generator and effecting an increase in energy in the boundary layer. The results to date suggest that the effectiveness is not high enough for most practical applications, but it is believed that slits rather than circular holes will be more effective. In contrast, a series of tests has been made in the wind tunnel on a 10 per cent thick symmetrical wing to determine whether the drag increment caused by blowing air out of spanwise slots near the leading edge is large enough for the system to be used as a dive brake. Drags of seven times the drag of the basic wing were measured with ram air pressure causing the flow through the slots. These results were obtained with no buffet troubles as the separated flow re-attaches to the wing near the trailing edge. Observing the trend to low aspect ratios on high-speed aircraft, the Aerodynamics Division has proposed a scheme for increasing lift at usable incidence which involves the ejection of air through perforated retractable tubes extending spanwise from the wing tips, and preliminary tests have shown promising results ; meanwhile, extra-mural work at Sydney University has included an investigation of the lift increases to be achieved by a jet projected from a wing tip outwards in both a spanwise and a 60 deg. downward direction, the tip slot extending over 80 per cent chord. The tests indicated that for very small values of the jet coefficient the increase in effective aspect ratio was slight, that there was a further range of C_J where the effect was very pronounced indeed, and that still higher C_J values caused the lift curve slope to approach very closely the two-dimensional case. Pressure plotting results showed a considerable increase in lift with small change in drag ; the spanwise jet gave the higher lift coefficients.

Boundary layer research in flight has begun with the Avro " 707A " aircraft, and a technique of full-scale flow visualisation is to have flight trials. A photograph of a model of the aircraft in a low-speed tunnel shows that it has the leading edge modified in the manner of a " Vulcan " ; the oil flow pattern shows that the flow has been separated from the leading edge in a vortex over the upper surface and remained so for some time. On a different scale, a cascade of blades were designed to stall at the design inlet angle, and separation prevented by suction through three spanwise rows of holes. Deflections up to 40 deg. were obtained, but separation on the blade ends and cascade walls prevents the corresponding static pressure being achieved ; experiments to eliminate this trouble and evaluate the suction required are continuing. At Sydney University, consideration has been given to the boundary layer in a duct bounded by a number of distinct walls. The interdependence of the boundary layers on these walls was studied for the case where the cross-sectional area changes slowly along the duct. It was shown theoretically that the layers on adjacent walls are then independent, but there is in general a boundary layer flow into, or out of, the corner ; this only swells or reduces the viscous region at the corner itself. When the cross-sectional area changes by more than a small fraction, however, the layers on adjacent walls are not independent.

The Structures Division has continued its work on fatigue, and in particular the study of the de Havilland " Dove " ; it is concluded that the life of this aircraft can safely be extended by modifying the centre section prior to a calculated time. The second most critical section is in the spar at the root of the outer wing ; a proposed modification involving the replacement of a " Duralumin " boom by steel was found merely to move the critical section to a different part of the wing without increasing its life. Other modifications are under consideration. It has been observed that the use of caustic pickles for " Duralumin " parts prior to anodising has been unacceptable in Britain and Australia as an outcome of tests done over twenty years ago. A series of tests was done on both L.40 and D.T.D.683, using a number of acid and caustic pickles, and treatment with 10 per cent caustic soda was found to give the best results, in most instances with an improvement in fatigue strength over the untreated material. This division has also studied the design of a 250ft diameter radio telescope on which deflections were critical ; a picture shows a proposal for a great bowl in the ground, with a more conventional reflector running on a track surrounding it.

The oxygen lance described in last year's report has been developed to the stage of flight test, but attempts were being made to stretch the performance of the test rig to a simulated 65,000ft, mainly to try an igniter with an outstandingly superior performance at altitude and with oxygen injections. Flight tests of the combined nozzle and igniter will take place in a R.A.A.F. " Canberra." Combustion work for ram-jet applications has evolved a " tunnel burner " in which oscillating flow occurs. It consists of a parallel tube with entries shaped to produce the required flow pattern ; the flame is stabilised on a wide angle diffusing cone and continues to burn in a parallel pipe. Using vaporised kerosene the peak efficiency was over 80 per cent and a stability range of 2 : 1 was obtained, these figures being slightly better than those for a normal ram-jet pilot burner. The pressure loss was, however, considerably less (60 per cent), which suggests that the " tunnel burner " may be more suitable for piloting ram-jet or after-burning systems.

The programme for the evaluation of chromium base alloys as turbine blade materials has been modified to include a thermal shock test. Preliminary running tests are to be performed on a converted turbo-charger. The achievement of ductility in chromium alloys containing small amounts of alloying elements has prompted intensive investigation of an alloy which has a chance of being ductile at room temperature. Hot working experiments with this material show that it can be extruded and also forged with closed dies. There has been some nitrogen pick-up during heating for forging, but experiments have indicated that the use of atmospheres of either purified argon or hydrogen will overcome this. The success attending hot working has caused the cancellation of attempts to cast blade shapes, which would have entailed vacuum melting to overcome nitrogen contamination. It has been shown that turning with normal tungsten carbide tipped tools is quite successful, and that grinding and spark machining can be carried out with certain precautions. The greatest trouble experienced was with surface cracking ; in the case of spark machining this could be made superficial and removed by electropolishing.

Extensions to a Stockton Works

A FURTHER stage has begun on the new South Works development scheme which was inaugurated a few years ago by Ashmore Benson Pease and Co. and The Power-Gas Corporation, Ltd., when it was realised that the existing works at Stockton-on-Tees were insufficient to provide for the rapidly increasing demands of the steel, chemical, nuclear power and other industries for process plant and associated equipment. For this development a new site of over 100 acres was acquired on the outskirts of Stockton, and under the first three stages of the programme there were built the large fabricating and machine shops described in our issue of July 29, 1955. The fourth stage, which was started in January by the firm, provides for the extension of the heavy machine bay and the construction of new medium and light machine bays, and the addition of a new high bay to the fabricating shop. At present, the heavy machine shop is some 250ft long by 100ft wide, and the extension to be made to one end will increase its length by 150ft. The new medium machine bay is to be built the full length of one side of the heavy bay and will be 105ft wide with a height of 35ft to the crane rails. On the further side of this medium bay there will be erected a 170ft wide by 410ft long light machine shop, which will also incorporate a finished parts stores and a tool room and jig stores.

Before deciding upon the layout of the new bays an extensive study was made in the old works of the facilities and services essential to the organisation of the extensions to ensure efficient machine utilisation, material handling and a degree of flexibility to provide for future requirements. Particularly, a comprehensive study was made of material flow between machines and assembly stations and overall crane requirements. It was decided to install cranes of 50 tons capacity in the heavy machining and assembly bay and of 25 tons capacity in the new medium machine bay, whilst 5-ton cranes could be used to satisfy all handling demands in the light machine bay. Further, if the cranes were designed to serve the whole of the floor areas in the medium and light machine bays, there would be no necessity to install cranes to serve individual machines as is the general practice in the older part of the works.

A study of the work flow made to determine the most suitable layout for the new shops, led to the preparation of a grouping scheme for machines so that in the new bays work will follow a natural operating sequence involving the minimum distance of movement of materials, which will always flow in one direction down the shop.

Structurally, the new light machine bay will be of particular interest, as it will provide an unobstructed floor area 410ft long by 170ft wide. The central 150ft width of the shop over its full length is served by 5-ton overhead suspension cranes. This clear floor area will give a wide measure of flexibility for the re-arrangement of machines for the introduction

of new plant when required, and facilitate the routing of materials and component parts from a stores extending down the full length on one side of the shop. The roof structure will be carried by nine braced portal frames of welded design and in which the main members are arranged in pairs to provide rigid box structures. These nine main box frames will be connected down the full length of the building by eight girders designed to support the tracks of the overhead cranes through suspension links.

The crane track down one side of the light machine shop will be provided with three 30ft span cranes. The two central tracks will each carry two 40ft span cranes, and, in addition, a crane of 80ft span running on both tracks. The remaining track over the stores area will have one 40ft span crane. The cranes will be installed with pendant floor control gear, although they can, when required, be provided with overhead cab control equipment. An interesting point in the design of the transverse tracks on which these cranes run is that they can be set in line across the width of the shop and linked together with latches. With this arrangement any required number of tracks can be aligned and a crab complete with its load can traverse across the width of the shop to facilitate movement without need for transferring loads from crane to crane.

The new shops will largely be equipped with machines transferred from the old works, although certain new machines will replace those which are out of date, and a number of new machines will be introduced. Amongst the new plant to be installed in the extended heavy bay will be a 6in spindle, ram type, horizontal boring and milling machine, with 40ft horizontal travel by 13ft 6in vertical travel of the spindle, and a 12ft diameter table vertical boring machine capable of machining parts 22ft diameter and weighing up to 50 tons.

Thrust-Boring Method of Culvert Construction

LAST week we attended a demonstration of a method of constructing a main drainage or water main culvert known as "thrust-boring." The method is advantageous when such services have to pass beneath a main road or railway, or as an alternative to deep trenching. It is not new in principle, the machine which is used being of American origin, having been developed primarily for the construction of oil pipe-lines, at situations analogous to those mentioned above, where some obstacle has to be tunnelled under. Use of the machine on other applications than oil pipe-lines is common in the United States, we understand, but it has only recently been used here for such work.

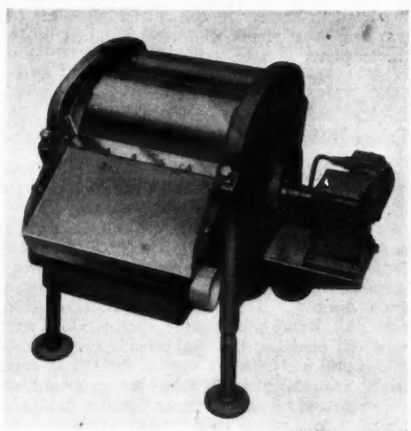
The thrust-boring machine is characteristic of much civil engineering plant of its class, being crude in design yet effective in operation. A length of steel tube, which can be up to 42in in diameter, is pushed horizontally into the ground ; a rotary cutter digs a hole in front of it and the spoil is removed through the tube by a screw conveyor. The cutter is slightly larger than the tube—the clearance is about 1in—so the tube can be freely edged forward as excavation proceeds. The outer teeth of the cutter are hinged, so by rotating the cutter and conveyor in reverse they can be withdrawn from the tube. There is no special bearing or guide for the cutter and the conveyor, other than the wall of the tube itself. The drive is from a 50 h.p. motor which "sits" on the pipe, on saddle bearings, and drives the conveyor and cutter shaft through chain-reduction mechanism.

The driving motor and saddle bearings are carried on a fabricated frame which also has a winch mounted at the front of it. The winch pulls the assembled frame and liner pipe forwards from an anchor, as the work proceeds. Small plates can be welded onto the pipe to take part of the forward thrust at the saddle bearings. When the pipe is driven horizontally to its full extent, another length is welded on. The cutter and conveyor operate at about 30 to 60 r.p.m. and, depending on ground conditions, progress up to a foot in two or three minutes can be achieved.

In the work which we saw, the engine frame has skids which bear on rails laid in the trench bottom. By setting the rails to level, and starting the bore by passing the tube through an accurately positioned hole in the steel sheeting of the trench, a degree of accuracy sufficient for drainage work can be achieved. This particular bore is under a busy railway line and traffic is being maintained on the line as work proceeds. The culvert is 2ft in diameter and is being driven for a distance of 130ft. Cast iron sewer pipes will be inserted, when it is complete, and then concreted into the culvert. This work is for the Staines main drainage ; the main contractor is Willment Brothers, Ltd., and the thrust-boring is subcontracted to Costain-John Brown, Ltd.

Coolant Separator

A NEW separator introduced by Rapid Magnetic Machines, Ltd., of Lombard Street, Birmingham, 12, is designed to remove impurities and sludge from suds and other coolants. The contaminated liquid is fed through a restricted area between the separator housing and a stainless steel cover of a magnetic drum. This drum is energised by powerful "Alcomax" permanent magnets fitted around its periphery, and it rotates in the opposite direction to the flow of liquid. Ferrous particles in the liquid attracted to the cover of the drum are discharged on to a chute at the front of the



Magnetic coolant separator for the extraction of fine ferrous particles from suds and coolants

separator after passing under a roller which squeezes out the liquid remaining in the sludge. The cleaned liquid flows from side outlets located near the front of the separator.

These separators, one of which is illustrated above, are available in capacities ranging from 10 g.p.m. to approximately 40 g.p.m., in increments of 10 g.p.m. The only electric supply needed is that for the motor which drives the magnetic drum. Whilst the drum is rotating, magnetic particles adhering to its face form a mechanical filter which also collects non-metallic abrasive particles.

Plastic Pipe Development

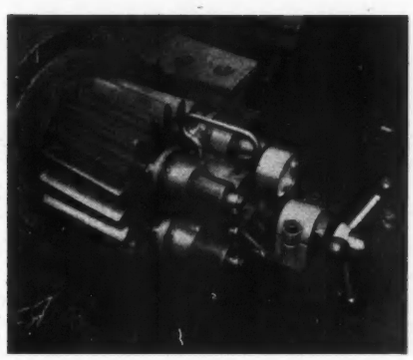
A NEW high-tensile polythene pipe has recently been introduced by Foster Brothers, Ltd., of Lea Brook Tube Works, Wednesbury, Staffordshire, in conjunction with Copper and Alloys, Ltd., the plastics division of the Delta Metal Company, Ltd. The material used is known as "Deltathene," and is extruded from "Hostalen," which is manufactured by the "Low Pressure" process covered by "Ziegler" patents. There is no difference in chemical composition between ordinary polythene and "Ziegler" polythene, but the manufacturing process gives the material a molecular chain which is longer and has fewer branches. The tensile strength of "Deltathene" is stated to average 3600 lb per square inch, compared with 1600 lb per square inch for ordinary polythene. The non-toxic qualities of both materials are identical, but the new material is said to have more resistance to chemicals and a greater resistance to abrasion, while its Young's modulus is $14 \cdot 2 \times 10^4$ lb per square inch, compared with $2 \cdot 56 \times 10^4$ lb per square inch for ordinary polythene. This latter fact has the effect of reducing stretch, such as occurs when laying pipe by mole ploughing, to about one-fifth of that ordinary polythene. The softening temperature is between 248 deg. to 264 deg. Fah., and the temperature range is from −22 deg. to a maximum of 192 deg. Fah. for a short period. For jointing the company recommends compression joints as against screwing, since the long continuous fibre structure renders the material vulnerable to any transverse cut and, in addition, there is the liability to "cold flow" under sustained stress, which might cause slackening of the joint.

The "Deltathene" pipe is similar in appearance to ordinary polythene, but has greater rigidity, so that supports may be spaced more widely. Last week we had the opportunity to witness practical tests carried out in a demonstration van fitted with hydraulic equipment. In the experiment short lengths of normal and heavy gauge pipes of ordinary polythene and a normal gauge pipe of "Deltathene" were mounted on testing heads and subjected to hydraulic pressure. The normal gauge and heavy gauge pipes of ordinary polythene burst at approximately 450 lb and 580 lb per square inch respectively, while the normal gauge "Deltathene" pipe successfully withstood a pressure of 1000 lb per square inch. The base material made by the "Ziegler" process is to be manufactured in this country by the Shell Chemical Company, Ltd., which has constructed a pilot plant, having a capacity of 1000 tons per annum of "Ziegler" polyethylene, at Partington.

Portable Hydraulic Pinion Press

A PORTABLE hydraulic press for fitting traction motor pinions, which, with appropriate adaptors, is suitable for all kinds of traction motors used on the Underground, has been developed by London Transport. This press is illustrated below and its use ensures that the thrust taken by the armature shaft is not transferred to the bearings, and that the driving force is applied evenly to the face of the pinion.

The press is used in conjunction with an adaptor attached to the armature shaft, and it consists of a plate carrying an adaptor socket

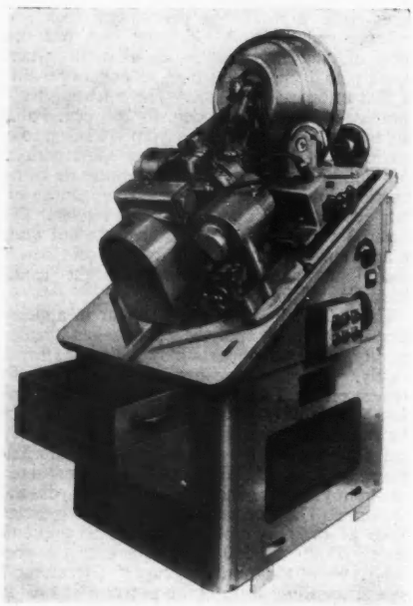


Portable hydraulic equipment pressing heated pinion on to the armature shaft of a traction motor

and fitted with four radial bosses in which there are four hydraulic plungers. A bracket attached to the back of the adaptor socket carries a hand pump capable of producing a pressure of 2500 lb per square inch. A maximum thrust of 2·7 tons can be exerted by the press through its hydraulic plungers.

The adaptor, which has a short shaft drilled to take a tommy bar, has a threaded socket at one end and a bayonet fixture at the other, which engages with a pin inside the adaptor socket of the press body. When using the equipment an adaptor is first screwed on to the armature shaft, to which the heated pinion is then fitted and pressed up by the plungers by operation of the hand pump. When the pinion has cooled pressure in the cylinders is released and the press and adaptor removed.

Screw Slotting Machine



Automatic screw slotting machine with steplessly variable speeds and feeds

A NUMBER of improvements have been incorporated in the "Roy" screw slotting machine, the latest model of which was recently demonstrated at the works of Automation, Ltd., Devonshire House, Vicarage Crescent, London, S.W.11. The machine is now designed to slot screw blanks ranging from 8 B.A. to $\frac{1}{16}$in and from $\frac{1}{4}$in to $2\frac{1}{2}$in long. Its production speed depends upon the material from which the screws are made, and can be up to 720 pieces a minute. Typical of the production speeds in mild steel are 225 pieces a minute when slotting $\frac{1}{16}$in countersunk blanks and 520 a minute of 8 B.A. blanks.

The general arrangement of the machine can be seen in the accompanying illustration. The compact cabinet base contains all the electrical equipment and the slotting mechanism is mounted on a forwardly inclined table. Screw blanks are loaded into the rear of a rotating hopper at the top of the machine and are carried up by a series of vanes to fall into a central fixed trough. From this trough the screws fall on to the top of two inclined plates, which are spaced apart a sufficient distance for the screw shanks to fall into the gap and support the blanks from their heads. The spacing of the plates can be adjusted in accordance with the shank diameter of the blanks being handled. The blanks gravitate down the chute formed by these feed plates, and any which overlap or fall across the top of the plates are thrown back into the hopper by a rotating star wheel in the exit orifice.

At the foot of the feed line the blanks are picked up in vee grooves machined in the face of a rotating work carrier, which has a stepless range of speeds up to 6 r.p.m. As the blanks are carried round they are retained in the grooves by a stationary retainer head opposite the work carrier. A laminated spring face at the transfer point of this head provides a degree of flexibility to prevent damage to the leading edge as the screw shanks are picked up in their grooves. As the blanks are carried past this spring-loaded section any which have over-size or bent shanks likely to damage the machine push the section back to actuate a micro switch, which stops the main drive. Shortly after the heads are carried past a pair of lightly loaded, spaced, arms on a shaft connected to the safety micro switch and over-size heads lift these arms and stop the main drive.

The blanks are clamped in their grooves for the slotting operation by a raised tungsten carbide insert in a removable section of the retainer head, which holds them firmly to prevent any tendency to rotate or move radially. The slotting cutter head is mounted on slides to give the necessary degree of adjustment to cover the blank range of the machine. Its spindle has a stepless range of speeds from 150 to 600 r.p.m. After the slots have been cut the blanks are carried off the clamping insert to pass on through a deburring section. Here the screw shanks are pressed against a knurled length on the retainer head, which serves to impart a turning movement to the blanks. A series of teeth on an inclined plate opposite the knurled section mill off the burrs on the underside of the heads of the blanks as they rotate.

As the blanks are carried on past the deburring section they are prevented from falling out of their grooves by a short length of curved plate until they are over an inclined chute leading down to a hopper in the front of the machine. The screws fall on to this chute, which has a perforated plate base, and as the screws gravitate down a spray of oil from above washes any adhering chips through the perforations to a settling tank below.

In order to cover the range of blank sizes the work carrier plate has a set of different sized vee grooves machined in each of its faces. To change the machine over from one blank size range to the other the carrier plate can be removed and reversed after the retainer head assembly, complete with the hopper, has been moved back on its slide by means of a crank handle. The carrier plate is retained by three socket head screws which can be quickly and easily removed. This head slide incorporates a means of fine feed as well as the coarse crank operated movement, and the fine feed is used to adjust the position of the head in respect to the carrier plate for the two ranges of shank diameters handled by the carrier plate.

Diesel Railcars for Northern Ireland

TWENTY-FOUR diesel railcars have recently been completed at the Dundalk Works of the Great Northern Railway of Northern Ireland and the first complete train will shortly be placed in commission, operating on the 10.30 a.m. ex Belfast and 5.30 p.m. ex Dublin "Enterprise" services, in replacement of the present steam train working. This train will consist of three powered cars and three intermediate non-powered coaches, but additional powered cars and additional coaches may be added to meet traffic requirements. Further services, both on the main and secondary lines, will be operated by the new railcars as they become available. Of the twenty-four cars, the first sixteen will be second class, the remaining eight cars will be composite first and second class.

The second-class cars have double-end controls and gangways both ends, which will enable them to be used either as single units or marshalled in any position in the train. The composite cars will have driver's controls at the forward end only, and gangway at the rear end only. The first-class seats will all face forward and be tiered to ensure an unrestricted view for the passengers. The engraving shows a second-class car.

Apart from the alteration in general layout, certain major changes from cars already in service have been made. The Associated Equipment Company, Ltd., vertical engine, fluid flywheel and free wheel have been retained, but the engine capacity has been increased from 9·6 to 11·3 litres, the horsepower at 1800 r.p.m. now being 150. The former five-speed pre-selective "Wilson" gearbox has been replaced by the four-speed non-preselective type, direct air operated, and which gives a maximum rail speed of approximately 80 m.p.h. in top gear. The throttle control is now hand-operated with "dead-man" device incorporated; the quick-release brake system has been improved by the provision of $1\frac{1}{2}$in diameter through pipes and couplings. Two rotary exhausters per engine are provided as formerly. Two 21in brake cylinders of the non-combined type are fitted on each rail-car, the vacuum reservoirs being carried under the headstocks. Automatic brake slack adjusters are fitted. The cars are electro-pneumatically controlled, which enables one, two, three or four powered cars, with or without up to four non-powered coaches, to form a train for multiple unit working.

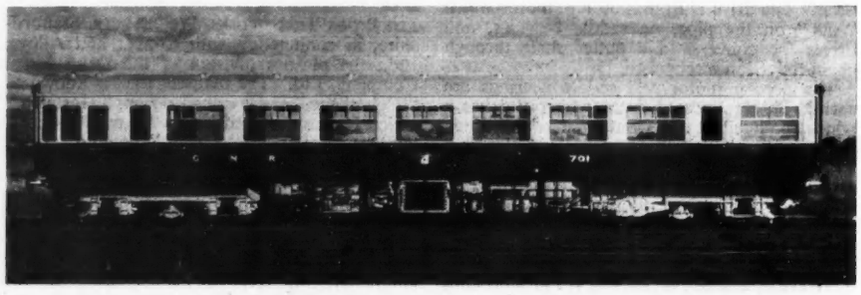
"Start" and "stop" buttons are placed beside each engine. Two starter buttons in each driver's cab operate, respectively, upon all right-hand engines and upon all left-hand engines. A single "stop" button in each cab stops all engines. Individual engine protection devices operate should there be cooling water or oil pressure failures. There are two hand controllers in each cab. One is a combined "dead-man" handle and engine control for five positions, and the other for engaging gears. The gear controller is interlocked with the direction selection lever.

The bogies are of more robust design than formerly, with the exception of the final drive axleboxes, which are of "B.U.T./Skefko" manufacture; all are of Hoffmann design. All axleboxes are provided with "Metalastik" bonded-rubber mountings instead of laminated spring suspension. The usual type of spring bolster with coil springs has been retained, but hydraulic dampers have been fitted to absorb vertical oscillations. Friction damping of bolsters is provided to deal with lateral shocks.

Uniform Sheet Wax

THERE is now available in this country sheet wax of an accurate thickness, made by the Kindt-Collins Company, Cleveland, Ohio, and imported by Astor Boisselier and Lawrence, Ltd., 9, Savoy Street, Strand, W.C.2. This product is principally for foundry and pattern shop use for reproducing the thickness of a finished part. For instance, if a female die is in existence, a sheet of wax of the appropriate thickness can be pressed into it by hand and the accurate shape of the male obtained by casting plaster into it, or, of course, vice versa. The material ranges in thickness from 0·007in to 0·375in, each gauge being held within 0·001in. The flexibility is such that a $\frac{1}{16}$in piece may be bent round a $\frac{1}{4}$in mandrel, and may be increased by dipping the wax in hot water: it melts at about 160 deg. Fah. It is available with a pressure sensitive adhesive on one side to render its application to any oil-free surface easy.

In addition to the regular "Master" sheet wax described above, there is a grade known as HT-260, which melts at approximately 260 deg. Fah. This has similar functions, with the advantage that its melting point is above the curing temperature of the resins used for casting and laminating. Thus plastics tools may be cast directly into or over a sheet of the wax. The material runs easily when melted. It is available to the same accuracy in thicknesses above 0·010in, and again can have an adhesive backing: each sheet is 12in by 24in.



Twenty-four diesel railcars have recently been built at Dundalk for the G.N.R. of Northern Ireland. This illustration shows a second-class car

Industrial and Labour Notes

Costs and Prices

In the May issue of its *Bulletin for Industry*, the Treasury says that there was a further rise in the level of prices in the United Kingdom during last year. The main cause was an increase in home costs brought about by money incomes expanding more quickly than output. When 1956 is compared with 1955, final output prices (i.e. total of the goods and services produced for consumption, investment and export) rose on average 4 per cent. But, the Treasury explains, although wholesale prices of manufactured products (excluding food, fuel and tobacco) continued to rise last year, the rate of advance declined fairly steadily, a trend which has been evident so far this year.

The *Bulletin* goes on to say that in manufacturing industry, which accounts for about two-fifths of national output, unit labour costs in 1956 appear to have risen rather more than in the economy as a whole. Profits per unit of output may have declined. The average annual earnings per employee increased last year by 8 per cent, largely on account of wage awards in the winter of 1955–56. But output per man-year fell by 2 per cent, the main reason being that, while demand and output dropped in some industries, the numbers employed did not fall proportionately, employers apparently preferring to hold on to their labour in the expectation of an early revival in demand and output. These figures, the *Bulletin* says, suggest an increase in unit labour costs in manufacturing industry last year of something like 10 per cent, after a relatively small rise in 1955, and none in 1953 and 1954. The upsurge in manufacturing industry's unit labour costs, and the accompanying rise in the cost of materials and fuel, did not, however, lead to a corresponding advance in prices ; the rise last year in the average level of wholesale prices of manufactures was limited to 4½ per cent.

As to the present position, the *Bulletin* observes that no major change in the average cost of imports seems likely in the months ahead. Commodity prices and shipping freights have fallen after their sharp rise during the Suez crisis, though they may well level out with a renewed advance in world economic activity. The course of this country's price level this year will, therefore, depend mainly on what happens to the relation between incomes and output. Wages have risen relatively slowly in recent months because, the *Bulletin* comments, settlements are taking longer to complete. Between October, 1956, and March, 1957, the index of wage rates rose by just under 1 per cent, compared with 5½ per cent in the corresponding period of 1955–56 and nearly 4 per cent in 1954–55. But it must not be overlooked that there have lately been a number of wage awards in the country's major industries.

Time Lost Through Disputes

The Ministry of Labour has stated that, during the month of April, there were 292 stoppages of work in progress in the United Kingdom on account of industrial disputes. The number of workpeople involved in them was 840,700 and the aggregate number of working days lost was 2,572,000. Most of the time lost, of course, was in the shipbuilding and engineering industries ; although the strikes in those industries ended on April 3, the number of people involved was 793,100, and the time lost in April was 2,436,000 working days. In the first four months of this year, the time lost through stoppages of work arising from industrial disputes was 6,772,000 working days, which was three times the number of days lost in the whole of last year.

Price Stability and Productivity

Reference to consultations to be held by the Chancellor of the Exchequer and the Minister of Labour with representatives of industry was made by the Prime Minister, Mr. Harold Macmillan, in a speech at Stockton last Saturday. The purpose of these talks, he said, was to discuss whether an independent body might help to throw light on all the different aspects of price stability and on the need for greater productivity to earn a higher standard of living.

The Prime Minister also spoke about the "handicap of restrictive practices." The Government, he said, was urging the trade unions and the employers to get together to do their utmost to deal with that handicap, and he was glad that progress was being made. The atmosphere of industry must be right, the Prime Minister added, and there must be a sense of partnership in a common enterprise ; that was the only way to reduce the danger of strikes, both official and unofficial. The more the workers knew of management problems, the more management understood the individual needs of the workers, and the more regular the consultation between management and workpeople, the stronger would be the sense of comradeship and co-operation.

The first of the discussions mentioned by the Prime Minister was held on Monday. Representatives of the Federation of British Industries and of the British Employers Confederation met the Chancellor of the Exchequer and the Minister of Labour.

Coal

The concluding session of the annual conference of the National Association of Colliery Managers, on Friday last, was addressed by the chairman of the National Coal Board, Mr. James Bowman. He spoke about the success of the Board's coal face mechanisation programme, saying that 25,000,000 tons of coal had been power-loaded in 1955, and that in 1956 the figure was 36,400,000 tons.

That advance, Mr. Bowman observed, was spectacular, and there were hopes that this year the total of power-loaded coal might be increased to 50,000,000 tons and possibly more. In the last quarter of 1956, Mr. Bowman continued, the average output a manshift had been 3·57 tons on conventional faces and 5·78 tons on those which were mechanised. In many instances, face productivity had been more or less doubled when power-loading was introduced. But, he went on, a new problem had been created with the rapid increase of the output of small coal and the falling proportion of large ; it was, in fact, the shortage of large coal which had made coal imports necessary this year. The steep increase in the use of explosives had been responsible in some measure, though a substantial contributory factor was the increasing rate of power loading with its "resultant degradation." The fall in the proportion of large coal must be expected to continue, Mr. Bowman said, unless measures could be taken to check it, in particular by the use of improved machines.

Mr. Bowman also had something to say about colliery disputes. The Board's aim, he commented, had been to set a new standard as employers ; to encourage high standards of loyalty and co-operation by example, and to use the positive tool of fair dealing rather than the negative one of the "sack." But, he urged, greater efforts must be made, for last year there were more separate disputes than in any previous year since vesting day. Disputes could be expressed in terms of tonnage lost, Mr. Bowman added, but that was no real measure of their effect. They destroyed the morale of management and workmen alike, and their total effect was incalculable.

Iron Castings Production

The Council of Ironfoundry Associations reports that the production of iron castings in the first quarter of this year, totalling 962,000 tons, was 1 per cent lower than in the preceding quarter and 7½ per cent lower than in the first quarter of 1956. The Council says that there were some signs, in February, of recovery from the relatively low output figures of the preceding quarter, but the strikes in the shipbuilding and engineering industries caused further setbacks in March.

The Council's report adds that the clearing of the Suez Canal and the derationing of petrol, together with the "settlement of most of the disputes in the shipbuilding and engineering industries" are factors which give some hope of improved output conditions in the future months of this year. In the automobile and building industries there are indications of renewed activity which can be expected to result in increased orders for iron castings. But the Council points out that the strikes continued into April, and it must therefore be anticipated that their effect on output will be noticeable in the production figures for the current quarter.

At the end of March the number of people employed in the ironfounding industry was 138,500. This was about 2000 fewer than at the end of last year.

Trade with China

An announcement about the United Kingdom's trade with China was made in Parliament last week by Mr. Selwyn Lloyd, the Foreign Secretary. He explained that the Government had decided that the strategic controls on exports to China should be aligned with the existing controls on exports to the Soviet bloc. In addition to nuclear energy and munitions items, these controls embargo or restrict exports of about 200 other items. There are goods, however, which hitherto have been embargoed only to China. They now become free of export licensing control for China, as they are for the Soviet bloc, and include certain machine tools ; some electric motors and generators ; rubber working machinery ; most motor vehicles and tractors ; railway locomotives, rolling stock and other railroad equipment ; most internal combustion engines ; certain scientific instruments ; rubber and tyres, and various chemicals.

Salon Internationale de l'Aeronautique

No. I

On May 24, the XXIIe Salon Internationale de l'Aéronautique was inaugurated at Le Bourget by Monsieur Bourgès-Manoury, Minister of National Defence, representing Monsieur René Coty, President of the French Republic. This is the third time that the Salon has been held at Le Bourget, where a large exhibition hall was opened for the XXe Salon in 1953. Previously the Air Show—which took place for the first time on September 25, 1909—was held at the Grand Palais on the Champs Elysées, until the growing size of aircraft made it necessary to look for a larger site. It was then decided to transfer the aircraft section to Orly, where demonstration flights could be given. The success of this move led to the decision to hold the exhibition in toto at an airfield, and the choice fell on Le Bourget. At the last Show in 1955 the number of spectators was 200,000. For this year's event there were 10,000 square metres of roofed exhibition space and 120,000 square metres of open-air exhibitions. Over 200 firms of the aircraft and allied industries took part in the event, which ended on June 2.

THE XXIIe Salon Internationale de l'Aéronautique, which opened at Le Bourget on May 24, impressed both by the number and quality of the exhibits and by the way they were presented. Of the nearly 230 firms and organisations which took part, some 170 are French, thirty are British, eleven are from the U.S.A., and seven Italian, the remainder being made up by nine European countries, including two German firms. Although from the point of view of numbers the French contingent preponderated—including, as it did, a very full cross-section of ancillary industries—the international character of the exhibition is well established by the British and American participation, and underlined by some interesting exhibits from other countries. The smaller items were displayed in the large hall, which was erected in 1953 near the Le Bourget airport building. Outside in the open-air enclosure, were full-sized aircraft, both civil and military, as well as helicopters, a number of missiles, and certain special designs, such as the "Flying Atar."

In our survey of the Salon we shall first turn to French military developments, where important advances are being achieved.

French Military Aircraft

Two versions of the Fouga jet trainer were on show, the Fouga CM 170 "Magister," and the CM 175 "Marine." The "Magister" (Fig. 1) has been widely ordered for the *ab initio* training of jet fighter pilots. It first went into use last summer. The machine has a span of 12·15m, a length of 10m, and the CM 170R version is powered by two Turbomeca "Marboré II" jet engines giving a thrust of 400 kg each. The slightly backswept main plane has an aspect ratio of 7·4. The hydraulically actuated high-lift flaps are of the area-increasing design. Air brakes are installed on the upper and lower wing surfaces. The main plane is a monospar, stressed skin structure. The fuselage is all metal, semi-monocoque, equipped with tandem pressurised cockpit and tricycle landing gear. The tail unit is a "butterfly" design. The aircraft has a wing area of 17·3 square metres, an empty weight of 2157 kg, and an all-up weight of 3165 kg. Maximum horizontal speed, without wing tip tanks, is 700km per hour; maximum Mach number equals 0·83. Rate of climb at sea level is 16m per second, and the ceiling is 12,000m.

The Sud-Aviation SO. 4050 "Vautour" is now in production for the French Air Force in the versions SO. 4050N (all-weather fighter), B (bomber) and A (tactical support), the two latter versions being on view at Le Bourget. The aircraft has an all-up weight of 15 to 20·7 tons and is powered by two Atar 101 E3 jet units; it is designed for Mach=0·9 in horizontal flight.

Next to the two "Vautour" aircraft one could see the S.E. 212 "Durandal" (Fig. 2). This light, delta wing, single-seater interceptor is fitted with a S.N.E.C.M.A. "Atar G" engine with afterburner, developing 4500 kg thrust, and a SEPR booster rocket giving 750 kg. Its design speed is of the order of Mach=1·6. Few details have been revealed about this aeroplane, which first flew in April, 1956.

Another delta, the S.N.C.A.N. "Gerfaut," about which little has been released, is to be seen later at Le Bourget. On February 16, Monsieur A. Turcat set up a world record in a "Gerfaut II" by reaching 15,000m in 3 minutes 56·3 seconds. This was followed by another flight on February 28, by Monsieur Michel Chalard, who reached 3000m in 51·2 seconds, thus exceeding the performance of the American "Skyray" for this height. The "Gerfaut II" is shown in the illustration Fig. 3.

Two versions of the Générale Aéronautique Marcel Dassault "Mystère" jet fighter were shown. The "IVA," a supersonic interceptor and tactical support aircraft, is powered by one Hispano-Suiza "Verdon" 350 engine, a development of the Rolls-Royce "Tay," with 3500 kg dry thrust. The aircraft which has been selected by N.A.T.O., French, Indian and other air forces, has swept wings of 11·115m span and an overall length of 12·889m. Armament consists of two 30mm cannon and, additionally, as alternatives, air-to-air or air-to-ground rockets, bombs or napalm bombs. The second design is the "Super-Mystère," of which the latest version, the "B2," first flew on February 26 of this year. Compared with the "IVA," the span is less (10·514m) and the length has been increased to 14·050m. Among other aerodynamic changes may be mentioned the modified air intake. Powered by a S.N.E.C.M.A. "Atar G" ("Atar E" with afterburner with up to 4700 kg static thrust), the machine reaches supersonic speeds in level flight. Its production has been ordered for the French Air Force.

Transport and Civilian Aircraft

The prototype of the S.N.C.A.N. Nord. 2501 "Noratlas" first flew in 1950, and the aircraft went into series production in 1953. In Fig. 4 we show the Nord. 2502, a civilian version which, in addition to the normal two Bristol "Hercules" engines with Rotol reversible pitch propellers, is equipped with two wing-tip Turbomeca "Marboré" jet engines. As a pure cargo plane

Fig. 1—A flight of Fouga "Magister" trainers

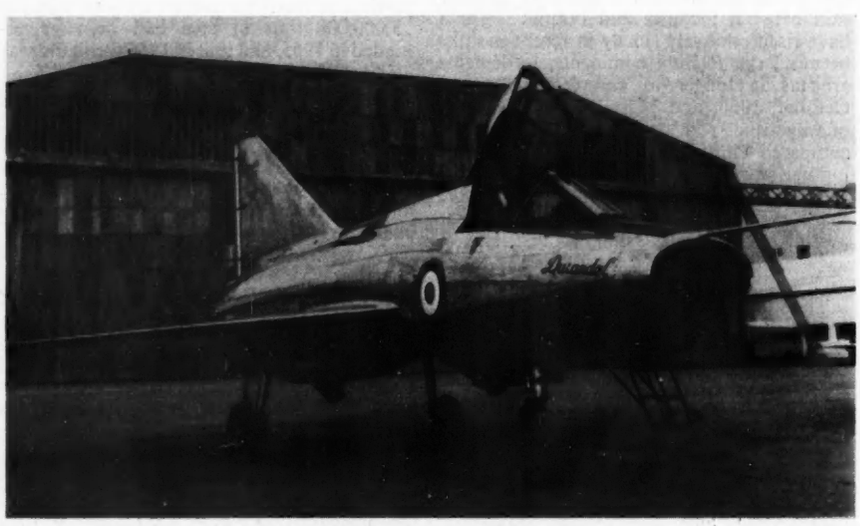


Fig. 2—"Durandal" lightweight interceptor

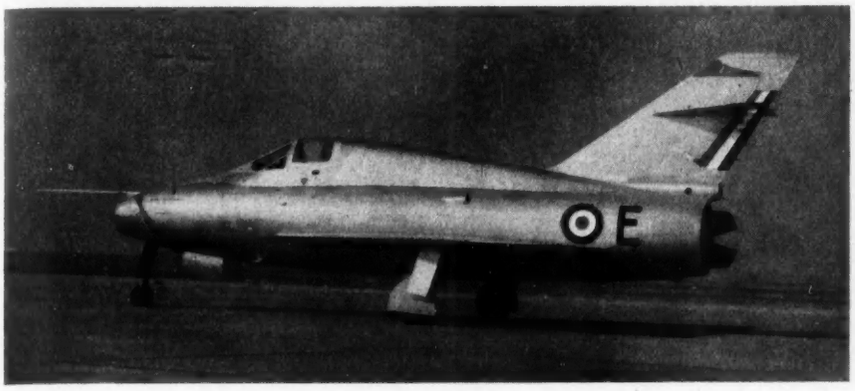


Fig. 3—"Gerfaut II" delta wing supersonic interceptor

Fig. 4—"Noratlas 2502" with wing tip jets

Fig. 5—"H.D.-34" the military version of the "H.D.-32"

of just under 13 tons, the aircraft can carry 7·7 tons of freight, making a total all-up weight of 22 tons. In the mixed passenger freight version, the load capacity is some 540 kg less. Other versions of the "Noratlas" are the "2503" with Pratt and Whitney "CB 17" engines, now being flight-tested; the "2504" flying anti-submarine school; the "2506" which has a landing gear designed for rough airfields of poor load-bearing capacity, the main portion of which can be retracted on the ground in order to facilitate loading; this version has special lift extension flaps. The "2507" is a land/sea search and rescue aircraft for a crew of twelve, with an endurance of twelve hours at 500m to 1000m.

Also shown was the Breguet 765 "Deux Ponts," a development of the Breguet 763 medium four-engined transporter. The "765" is 29m long, has a span of 43m, and a height of 10·2m, and has an all-up weight of 54 tons. Powered by four Pratt and Whitney "C.B. 16"-"C.B. 17" engines, it can carry 17 tons of freight or 126 to 164 passengers, at a maximum cruising speed of 400km per hour. Fitted with two decks, its fuselage of 167 cubic metres represents a floor space of 81·5 square metres. The range is 4000km. For the last five years twelve aircraft of this kind have been in use on Air France Mediterranean routes, covering over 19,000,000 km and carrying 1,850,000 passengers. A military transport is under construction.

The twin-engine Hurel-Dubois H.D. 32 is designed for carrying forty-eight passengers or 5·5 tons of cargo, or a combination of passengers and cargo, over a range of 1000km, the maximum range being 2000km. As a military transport (Fig. 5), it can carry sixty men and equipment, or thirty-two stretcher cases with three crew and four attendants. The aircraft, which first flew in February, 1955, about two years after the prototype version, has an overall length of 21·638m and a span of 45·160m, with 5 deg. dihedral. The high aspect ratio of 20·2 results in a small induced drag and makes possible a flap position of 20 deg. for take-off and 45 deg. for landing. Take-off speed is stated to be 158km per hour, and with its maximum all-up weight of 18·7 tons, the distance for clearing an obstacle 15m tall is 750m. With a weight of 18 tons, the landing distance is 350m (630m from 15m altitude). Two Wright "Cyclone 9HE" of 1525 h.p. are fitted. The aircraft can take off on one engine under full load, climbing at 1·45m per second.

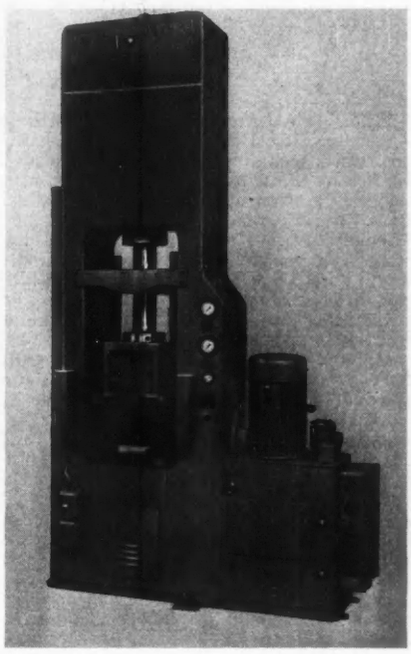
Built by Miles Aircraft, Ltd., Shoreham, the HDM-105 has an M.57 "Aerovan" fuselage and Hurel-Dubois wings. This aircraft, which first flew in April, is powered by two "Cirrus Major" engines. Its development is the result of co-operation by Société de Construction des Avions Hurel-Dubois and Miles Aircraft, Ltd., which in 1955 formed a joint company, H. D. and M. (Aviation), Ltd. The next stage is to be the HDM-106, with an all-up weight of 8000 lb and equipped with two Lycoming "GO-480" or "GSO-480B" engines. The aircraft is a multi-purpose passenger/cargo plane.

(*To be continued*)

Oil-Hydraulic Multi-Purpose Press

A recent development in the field of press design is the "Model UWK" multi-purpose, oil-hydraulic press shown in the accompanying illustration. Made by Becker and van Hüllen, Krefeld, Untergath 100, West Germany, the press is intended for the production of small components by deep drawing, and for work such as coining, assembly of press fits and straightening of bent parts. Three versions are being made with capacities of 63, 100 and 160 tons. The closed frame is of welded plate construction. A stepless variable drive is built on. The top of the frame is arranged as an additional oil tank for prefilling the working cylinder.

For deep drawing a pneumatic or hydraulic blank holder is provided, as well as an adjustable ejector for the completed parts. Top and bottom platens have tee-slots for the press tools. Operation is either by manual control or semi or fully automatic by means of press-button control.



Oil-hydraulic multi-purpose press

The control lever operates, by means of a servo cylinder, the swash plate and outer casing of the multi-piston radial and axial oil pump.

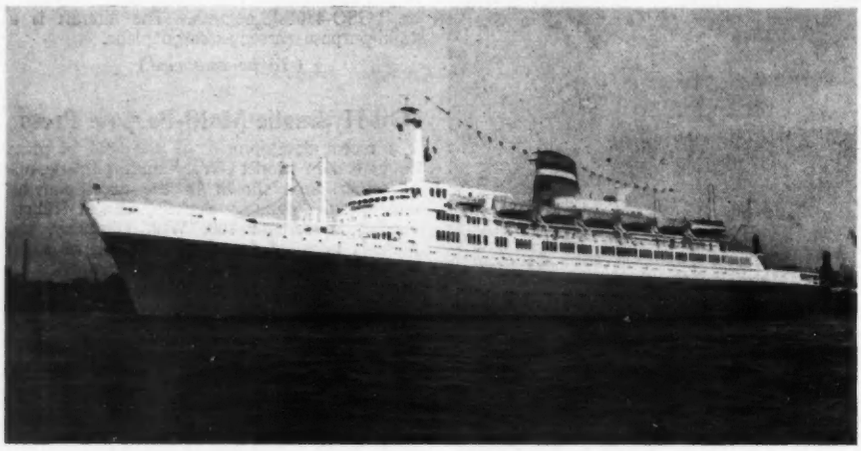
With the lever in the neutral position, the output of the pump is zero, while moving the lever in the opposite direction reverses the pump.

In this manner a delicate speed adjustment is obtained. Automatic speed variations during the stroke are brought about by means of interchangeable cam plates fitted to a rail at the back of the press, which moves up and down with the ram. The same rail carries the two cam plates serving as adjustable end stops.

Approach speed is about 20m per minute, which is automatically reduced, by means of the cam plates, to the correct drawing speed, just before the press tool closes. After the bottom position has been reached, the press reverses either on reaching a certain pressure or after the lapse of a certain time interval, and the ram returns with maximum reverse speed.

The maker is represented in this country by Arpal (Engineers), Ltd., Abford House, Wilton Road, London, S.W.1.

Holland America Liner "Statendam"



The Holland America Line is now operating in its North Atlantic service the liner "Statendam," which has a length overall of 642ft 3in, a tonnage of 24,294 gross, and carries eighty-four first and 868 tourist passengers. A service speed of 19 knots is maintained by two sets of double reduction geared turbines developing 20,000 service s.h.p. at 117 propeller r.p.m.

RECENTLY there entered the North Atlantic service of the Holland America Line a new liner which was given the name "Statendam" by Her Royal Highness Princess Beatrix, at a ceremony performed during the vessel's official trials. The ship, which was built and engined by Wilton-Fijenoord N.V. Dok-en Werf-Maatschappij in its dry dock at Schiedam, is the fourth ship to bear this name. The first, which was in service from 1898 to 1910, was a ship having a length of 515ft by 59ft beam, and a speed of 14 knots and accommodation for 1486 passengers, while the second, of 32,120 gross tons, had a length of 770ft by 86ft beam and a speed of 18 knots. This ship was built by Harland and Wolff, Ltd., and launched just before the first world war; she was torpedoed and sunk in 1918. The third "Statendam," which sailed on her maiden voyage in 1929, had a length of 696ft, a speed of 19 knots, accommodation for 1714 passengers and a gross tonnage of 28,291. Like her predecessor, this ship became a war casualty and was burnt out at Rotterdam in 1940.

Our illustration shows the new liner, which has a pleasing profile incorporating a large single aluminium alloy funnel, a built-up mast, a curved and raked stem, and a cruiser stern. There is a total of nine decks, all of which, either mainly or in part, are used for the accommodation of passengers and crew.

The following are the principal particulars :—

Length overall	642ft 3in
Length between perpendiculars	578ft 2½in
Breadth	78ft 9¼in
Depth to "B" deck (bulkhead deck)	33ft 4¾in
Depth to promenade deck	60ft 8in
Draught maximum	26ft
Deadweight	6,750 tons
Tonnage, gross	24,294 tons
Tonnage, net	13,879 tons
General cargo capacity (bale)	120,000 cubic feet
Service speed	19 knots

Accommodation

First-class passengers	84
Tourist-class passengers	868
State room	403
Officers	44
Crew	392

Main and Auxiliary Machinery

Type : Two sets of double reduction geared Pametrada turbines.
Power : 22,000 s.h.p. at 120 propeller r.p.m.
Steam supply : 625 lb per square inch at 850 deg. Fah.
Boilers : two Foster Wheeler boilers.
Type of generators : Four turbo-electric alternators.
Rating : 700kW, 440V, a.c.

Accommodation

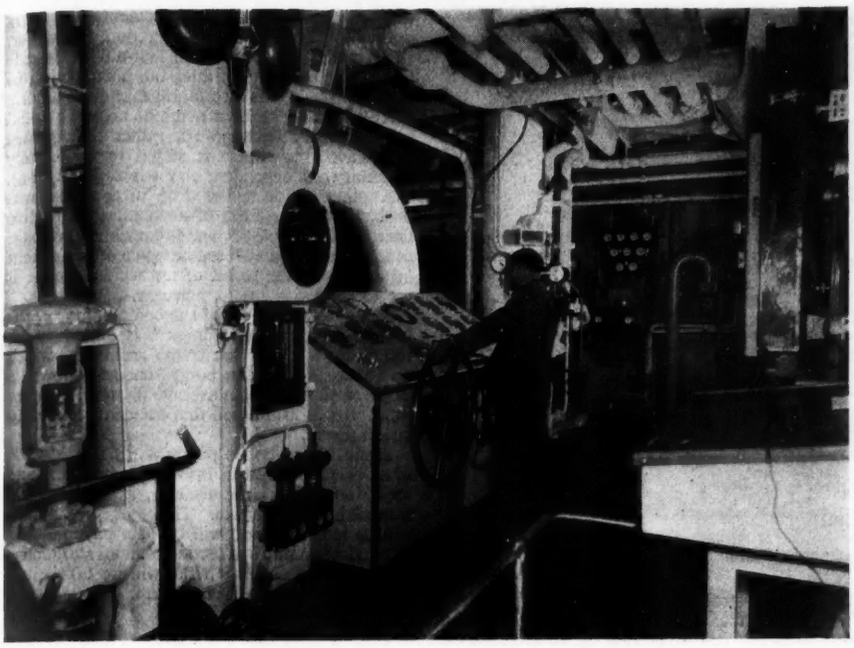
The cabins for the first-class passengers are on the bridge and upper promenade decks, and all are outside cabins having showers or baths. At the aft end of the upper promenade deck are the public rooms, there being a combined club room and bar to starboard, which is panelled in ash and Rio rosewood, and has as the main decoration a bronze sculpture representing the Dutch struggle to reclaim land from the sea. To port is the restaurant having tables for two and four persons, and a total seating capacity for eighty-seven; it is decorated with a cast bronze screen. Aft, and having doors opening on to the deck, is the drawing room, which extends for the full width of the deckhouse and has panelling of bleached ash and Rio rosewood and a large tapestry as the main decoration.

The tourist passengers, who have been given the run of the greater part of the ship, have their state rooms on the main, "A," "B" and "C" decks. Most of the public rooms are on the promenade deck, right forward being the observatory panelled in ash and grey "Vynide" and decorated with paintings depicting the four winds, and a multi-coloured relief showing the discovery of the New World. Immediately aft, on the centre line, is the library, which is finished in Honduras mahogany, while to starboard is the ocean bar, with walls covered with stained ash and beige "Vynide" and decorated with humorous line drawings. On the opposite side of the ship is the card room, having eucalyptus wood panelling, part of which is covered by a tapestry representing card games. Both these rooms open into the lounge, illustrated herewith, which is a large room able to accommodate 460 passengers and designed as the social centre of the ship. The panelling is of Rio rosewood and the principal decorations are hangings picturing a garden party and ceramics depicting the four seasons. From the aft foyer doors lead to an ante-room to starboard and to the aperitif bar to port and, continuing aft, both rooms lead to the smoking room, in which concave walls in the centre space are decorated with ceramic figures symbolic of hunting, while the rest of the room is panelled in mahogany and "Vynide." Right at the aft end of the deckhouse and adjoining the smoking room is the verandah with its cherry panelling. On "B" deck is the dining room, part of which can be seen in our illustration, having tables for two, four, six and eight, and able to seat 530 passengers. The walls are covered in eucalyptus and off-white "Vynide" and the decorations consist largely of glass reliefs, mosaics and large mirrors.

On "C" deck, there is a cinema which has a total of 340 seats and is available for both classes of passengers. It is equipped with an electric organ and is arranged so that church services may be held there. On the deck below is a swimming pool, which is decorated with glass mosaics, and adjoining is a gymnasium, Turkish baths and massage rooms. There are extensive enclosed and open promenades and adequate space for the playing of games on the sports deck, at the forward end of which is a children's play room. There is a large open space

Tourist lounge on promenade deck, looking to starboard and aft

Part of tourist dining room on "B" deck, looking aft on starboard side



Manœuvring platform at forward end of engine-room, showing control desk for port set of turbines

at the aft end of the promenade deck and also an open-air swimming pool. The main staircase extends from the sports deck down to "D" deck, to link foyers at all levels, and is flanked by two lifts, each of which has a duty of 1650 lb at 200ft per minute. The deck officers and engineer officers have their cabins arranged on the bridge deck with the captain having his suite forward and to starboard, and there is a service lift for the engineers.

Ship Services

The whole of the accommodation for both passengers and crew is air conditioned, there being thirty-one units of 15,384,000 cubic feet per hour total capacity. The cooling duty is performed by two "Carrier" centrifugal plants, of 9,523,000 B.Th.U. per hour capacity, having turbine-driven compressors. Heating is by means of a hot water system which operates in conjunction with a spray installation, to ensure correct humidity, and the water is circulated by two pumps having a combined capacity of 364 tons per hour. A Griscom-Russell distilling plant provides the drinking water and consists of two units with a capacity of 260 tons per day. Ten compressor units draw on the distilling plant pipelines and supply ice water to various points throughout the ship. The main galley, which is mainly all-electric, and associated food-preparation rooms and kitchens are on "B" deck aft of the tourist dining room and linked with the stores on "C" and "D" decks by two special lifts, each rated to handle a load of 2250 lb at 100ft per minute. Four lifts also connect the galley with the pantries and the first-class kitchen on the upper promenade deck, and each has a duty of 165 lb at 100ft per minute. A fully equipped laundry is located aft on "C" deck, and there is a complete medical block aft on "B" deck. The ship is fitted with the "Pneupress" system and the refrigerating plant for dealing with cargo and domestic cold chambers, totalling 56,700 cubic feet, consists of three Sterne twin-cylinder monobloc compressors and condensers which are situated in the shaft tunnel between the shafts. In a compartment forward of the boiler-room is the Denny-Brown stabilising equipment, each fin having an area of 70 square feet and able to turn through 20 deg., at which angle it exerts a force of 54 tons at 20 knots.

The three holds, two forward and one aft of the superstructure, are fitted with MacGregor Comarin steel hatch covers and served by six 3-ton derricks operated by electric winches of 3·5 tons capacity at 135ft per minute. For handling the anchors there is an electric windlass, having a pull of 22 tons at 25ft per minute, the motor of which also drives two warping capstans, each able to exert a pull of 15 tons at 40ft per minute. On the main deck aft there are three capstans having a capacity of 20 tons at 30ft per minute. The sewage plant for the ship has been supplied by Adams-Hydraulics, Ltd.

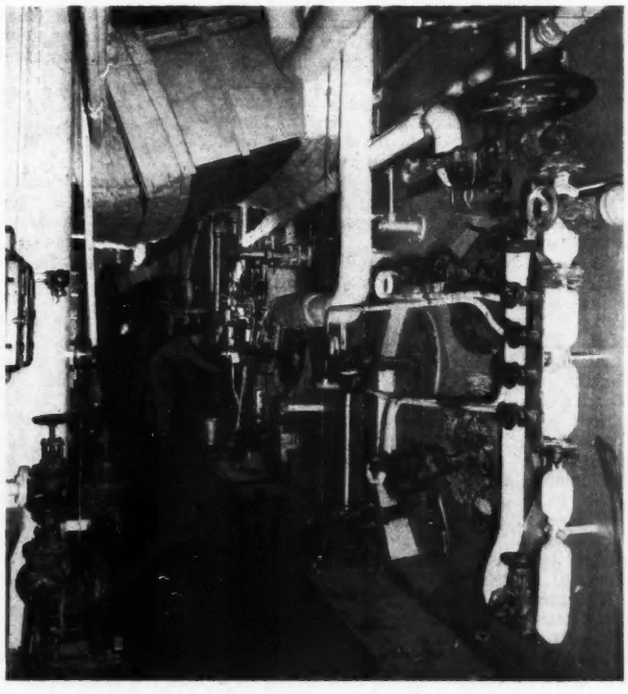
Safety and Navigation

The ship has been constructed in accordance with and in excess of the requirements of the International Conference for Safety of Life at Sea, and conforms with rules of Lloyd's Register and the American Bureau of Shipping. There are twelve watertight bulkheads extending up to "B" deck, and twenty-four sliding watertight doors, which can be operated electrically from the bridge or locally by hand, and which employ Stone's system of control. Precautions against fire are extensive and comprehensive, there being transverse and longitudinal fire-proof bulkheads between the passenger accommodation and the machinery spaces, cargo and service installations and a large number of self-closing fireproof doors which isolate one section from another. A Grinnell sprinkler system, grouped in twenty-four sections, is installed, while in the cargo spaces is a combined smoke detecting and CO_2 fire-extinguishing system, all associated with alarm panels. In the engine and boiler-rooms total flood CO_2 and foam equipment is installed. There is a complement of twelve aluminium alloy lifeboats, ten of which have hand-operated propellers and a capacity of 135 persons, while two are motor driven and have a capacity of forty-three persons. All are carried in gravity davits, and are equipped with tackle which keeps them close to the hull even when there is a list. In addition, there are two cruise tenders, each driven by a Perkins S.6 diesel engine, and able to carry sixty-five persons.

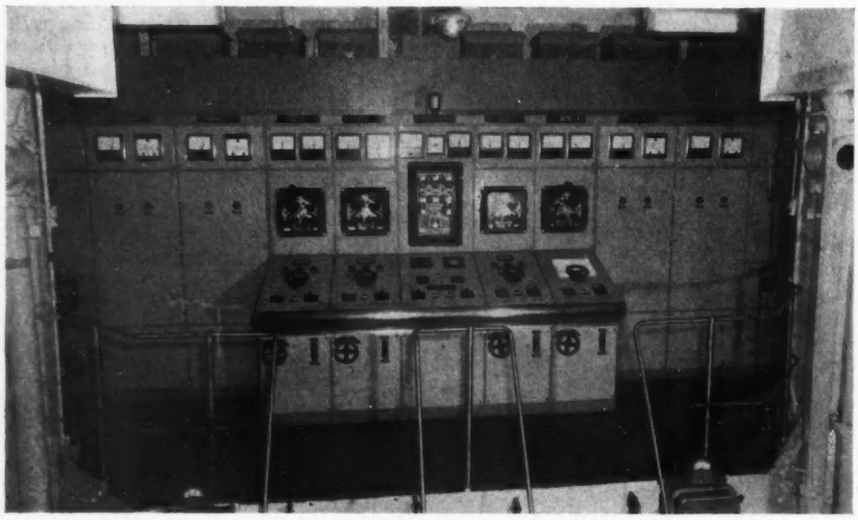
The "Statendam" is fitted with Sperry navigation and steering control system, including a gyro compass and a gyro pilot installation, with two bridge control units in the wheelhouse. These units, either of which may be used for hand-electric or automatic steering, and connected by a control panel containing the change-over switch, and an enlarged scale steering repeater. There is a Sperry Mark 3 radar, having dual transmitter receivers, installed and Loran equipment for determining the ship's position in the Atlantic and American coastal waters. A similar service is performed by a Decca "Navigator" in the English Channel and the North Sea.

Main Propelling and Auxiliary Machinery

Power for propelling the liner is developed by a two-shaft arrangement of Pametrada designed cross compound, condensing, double reduction geared steam turbines, constructed by the ship-builders, which are arranged in a well-planned engine-room. Each unit has a maximum output of 11,000 s.h.p. at 120 propeller r.p.m. and 10,000 service s.h.p. at 117 propeller r.p.m. For astern manœuvring there is available 6000 s.h.p. at 103 propeller r.p.m. from each installation. The engines consist of h.p. and l.p. turbines, the h.p. turbine having reaction blading and the single-flow l.p. turbine being of impulse-reaction design both incorporating astern wheels. At full power the h.p. turbine develops 6150 h.p. and the l.p. turbine 4850 h.p., the corresponding figures at service power being 5600 h.p. and 4400 h.p. respectively, while of the total astern power, 1800 h.p., is developed in the h.p. turbine and 4200 h.p. in the l.p. turbine. The double reduction gearing, designed and built by the Maag Gear-Wheel Company, Ltd., of Zurich, is of articulated pattern with single helical gears in both reductions, and is housed in cast iron casings. Nickel-chrome steel has been used for both the first and second reduction pinions and nickel-chrome-molydbenum heat-treated steel for the gear wheels. The primary and secondary trains are connected by quill shafts. The pitch circle diameters at the h.p. first reduction are 9·57/56·3in, with a face width of 11in, and the corresponding data at the l.p. first reduction is 13·9/52in and 9·5in. At the second reduction the pitch circle diameters are 20·5/133in and the



Stokehold, looking from starboard to port across boiler fronts



Control desk and main switchboard

face width 18in. Forced lubrication is effected by three vertical oil pumps, each capable of delivering 22,000 gallons per hour against a head of 115ft. Included in the system are Vokes filters, magnetic strainers, De Laval purifiers, a heater and Serck coolers. Control of the main machinery is from two desks arranged, one above each set of turbines, in a transverse flat at the forward end of the engine-room. One of the desks can be seen in our illustration.

The ship is equipped with a Weir closed feed system consisting of six extraction pumps, two air ejectors, a combined l.p. heater and drain cooler and two turbine-driven main feed pumps, each of 27,000 gallons per hour capacity, also one feed pump of 6500 gallons per hour capacity, for harbour use. For circulating the condensers there are four Drysdale pumps, each able to deliver 6230 gallons per minute against a head of 29ft and three auxiliary pumps of 2930 gallons per minute capacity against a 39ft head. Drysdale and Co., Ltd., has also supplied a number of other pumps, including three cooling water pumps rated at 917 gallons per minute against a head of 33ft ; four bilge and ballast pumps of 150 tons per hour against a 78ft head ; two fire service and one emergency bilge pump, all of 90 tons per hour against a head of 230ft ; and two 60 tons per hour sanitary pumps. Among the other auxiliaries are two Reavell air compressors, each rated to deliver 60 cubic feet of air per minute at a pressure of 113 lb per square inch and two 50 tons per hour oil fuel transfer pumps.

Steam is generated by two Foster Wheeler "D" pattern two-furnace controlled superheat boilers at 625 lb per square inch and 850 deg. Fah. A view of the stokehold is given in one of our illustrations. There are four burners in the saturated furnace and five in the superheated furnace, and the oil burning equipment is of Todd design. The boilers operate under conditions of forced and induced draught. The fans, of Stork design, consist of two forced draught units rated to deliver 29,000 cubic feet per minute against a discharge pressure of 7·2in water gauge and two induced draught fans able to deal with 30,800 cubic feet per minute against a pressure drop of 5·6in water gauge. The fans operate under Bailey pneumatic controls.

To meet the demands for electrical power there are four 700kW at 440V self-contained geared turbine-driven alternators, which are arranged two to port and two to starboard on flats in the engine-room wings. Werkspoor N.V. built the five-stage impulse-reaction turbines, (under B.T.H. licence), which are designed to take steam at 570 lb per square inch gauge and 830 deg. Fah. The turbine speed of 6000 r.p.m. is reduced to 1200 r.p.m. at the alternator through a 5 to 1 single-reduction double helical gearing. For emergency purposes there is a compartment on the sports deck, a 250kW at 440V generator driven by a six-cylinder single-acting, four-stroke M.A.N. diesel engine. The main switchboard, seen in our photograph reproduced herewith, is sited on a flat at the aft end of the engine-room and has a length of 40ft.

Ventilation of the machinery spaces is effected by fans supplied by Woods of Colchester, Ltd. Two supply and two exhaust fans serve the engine-room; each is a 48in "Aerofoil" fan having a capacity of 35,000 cubic feet per minute against 2in water gauge. Two fans of similar capacity supply air to the boiler-room.

Safety Competition

For many years, problems of accident prevention have formed one of the chief objectives of personnel management at Hüttenwerk Oberhausen which, during the last four years, has shown the lowest accident rate of all metal producers and rolling mills insured with the Hütten und Walzwerks-Berufsgenossenschaft. Compared with the average monthly rate per 1000 employees, the figures for Hüttenwerk Oberhausen are as follows :

	Average	Oberhausen
1953	13·0	9·7
1954	12·5	7·2
1955	12·6	7·1
1956	11·6	4·0

The company attributes these results to current improvements in technical equipment and protective gear, special courses for certain groups of workers, the training of new personnel, employment of "guardians" for student trainees and apprentices, and training of managers and supervisors.

In addition, a system of money rewards was instituted for the first time last year, in which every employee whose section showed a decline in accidents received a bonus at the end of the year. For this purpose, the whole of the works was subdivided into 160 sections, each of which received a certain "accident handicap," based on the preceding year's accidents. If the number of accidents decreased by one, each man on average received DM.20, the bonus rising to a maximum of DM.120 for no accidents.

At the end of the first year's operation of this novel scheme, the company professed itself satisfied with results. While a reduction of 15 per cent in the number of accidents had originally been expected, an overall reduction of 35 per cent was in fact realised, representing a decrease of 42 per cent per 1000 employees. Of the 160 sections, thirty-seven sections, or 24 per cent, were wholly accident-free, and over 70 per cent of employees succeeded in obtaining an improvement. The average bonus amounted to DM.45.

During the whole year the number of accidents and current premium rate were displayed in each section, thereby introducing the element of competition with other sections. At first, the large reduction in accidents was thought to be due to a number of minor accidents not being notified. Statistical investigation, however, showed that the decrease in first-aid treatments was larger before than after the introduction of the scheme. It was also found that more among those who had suffered a minor accident opted for temporary lighter work rather than go on sick leave (the choice is stated to be entirely voluntary and dependent on medical permission).

Another factor in the drop in accidents was probably the abolition of a voluntary collective insurance scheme by which lump sums were paid to those who had suffered a degree of permanent incapacity as the result of an accident, even if the accident was due to their own carelessness.

The beneficial effect of the competition on the general "safety mindedness" is stated to be shown by the fact that traffic accidents—which do not come under the bonus scheme—showed a decrease similar to the average figure, i.e. 36 per cent. It was also noted that accidents tended to be less severe.

Against total bonus payments of DM.350,000 must be set savings in insurance premiums and reductions of sickness benefits, as well as substantial indirect savings. This year, the bonuses will be increased and will become payable even if the accident rate in a section remains stationary. Differences in accident risks will be taken into account in assessing the handicap.

Ceramic Cutting Tools

Sintered alumina cutting tools have been made in Sweden for many years by Söderfors Bruk, Söderfors, under the trade name "Realox." The material consists of aluminium oxide, embedded in a matrix of magnesium oxide and quartz, and has a hardness of the order of 1400 VPN, as compared with a hardness of pure aluminium oxide of about 2000 VPN. "Realox" has a tensile strength of 40 to 55 tons per square inch. Transverse rupture strength is about one-fifth of that of tungsten carbide and the modulus of elasticity is about one-third smaller. Of technical importance are the low thermal conductivity (10 to 30 per cent of that of carbide) and the fact that the material does not weld to steel or other metals (so that no build-up edge is formed). Cutting speeds of 480ft per minute have been realised with steel of 230 Brinell hardness, using a feed of 0·12in together with a depth of cut of 2in. With softer steels, cutting speeds of 1500ft per minute and over have been achieved.

One difficulty with using ceramic tool bits is that of clamping them satisfactorily to a shank. One method is to use mechanical clamping, another is to spray the underside of the bit with silver and then copperplate it electrolytically. This enables soldering to be carried out.

A novel method which Söderfors Bruk is developing, consists in incorporating sintered metal in the ceramic mass, the proportion of metal increasing towards the bottom surface, which can be soldered in the normal manner.

La Mont Boiler Conference

A conference on operational and maintenance experience with forced and controlled circulation La Mont boilers, organised by the La Mont International Association, London, was held in the second week of May at Versailles, France.

Some thirty delegates of member firms in Great Britain, France, Belgium, Holland, Denmark, Germany, Italy and Spain attended the meeting, in the course of which fourteen papers were presented and discussed. The various papers dealt with experience on steam generating plant, including waste heat boilers in steel works, the oil industry, in chemical and paper manufacturing ; diesel exhaust gas boilers in ships, and high-pressure hot water plant. A notable development is the application of forced circulation in door frames of open-hearth furnaces. Design problems of very large power station boilers were discussed and novel arrangements of the evaporating circuits proposed. One paper dealt with circulation aspects of a large plant which is at present under construction. The technical and economic prospects for atomic power stations as seen in the spring of 1957 were discussed in another paper.

International Atomic Exposition at Philadelphia

BY OUR AMERICAN EDITOR

No. I

The third International Atomic Exposition was held at the Convention Hall in Philadelphia, Pennsylvania, from March 10 to 15, in conjunction with the second Nuclear Engineering and Science Congress. The exhibition was organised under the sponsorship of the American Institute of Chemical Engineers in co-operation with four other engineering institutions and was attended by some 10,000 visitors. It presented a comprehensive picture of the current state of development in the application of atomic energy in American industry, and this article reviews certain exhibits of particular interest.

ABOUT fifteen months elapsed between the recent International Atomic Exposition held in Philadelphia and the original one held in Cleveland at the end of 1955. During the interval, there has been a remarkable effort by the engineering industry, in the United States as much as in the United Kingdom, to enter the field of nuclear energy and to obtain a foothold in one or the other specialised aspect of its many industrial applications. Compared to the more recent British developments, American progress has been relatively slow, particularly in the important field of electrical power generation. No doubt, this is at least partly due to the fact that the United States still has ample future supplies of "conventional" power and thus does not face the necessity to have atomic power stations in operation as soon as possible.

American progress continues to be outstanding in the field of nuclear research and development, and both the U.S. Atomic Energy Commission and private industry have continued to design and build a variety of research reactors. Many of these non-military developments formed the subject both of displays at the exhibition and papers at the congress. Although the papers presented included several from abroad, the conference represented an almost exclusively American point of view. Each of the papers presented was sponsored by one of the twenty-four participating scientific and engineering institutions. The "International Atomic Exposition," which was held in conjunction with the Nuclear Engineering and Science Congress, included nearly 150 exhibitors from the U.S. and abroad, and was sponsored by the American Institute of Chemical Engineers. The displays offered covered such items as design engineering services, package power reactors, medical and research reactors, construction and fabrication techniques, controls systems, reactor materials, instrumentation, particle accelerators, measuring instruments, laboratory equipment, fuel elements and other reactor components.

Commenting on the outcome of the congress, Dr. Walter G. Whitman, its chairman, said: "I think that one of the most significant things about this meeting, aside from the technical information exchanged, is the extraordinary interest shown by engineers and scientists in bringing the practical results of nuclear research down to a working level for peacetime applications. The number and enthusiasm of the people who attended were most encouraging. So was the interest shown by the general public, the Press, and particularly the youngsters of high school and college age who received a constructive, enlightened introduction to this rapidly growing field." Altogether, more than 200 technical papers and panel sessions were presented during the congress. The highlights of the week included speeches by Dr. Kenneth W. Davis and Admiral Paul F. Foster, who are in charge, respectively, of reactor development and international activities at the A.E.C. Other speakers were Alfred Iddles, president of the Atomic Industrial Forum and of the Babcock and Wilcox Company, who read a special "Message from EURATOM," outlining the current plans of the European agency; Representative Carl Durham, the chairman of the Joint Congressional Committee on Atomic Energy; Carlos A. Bernardes, the president of the United Nations' Preparatory Commission, International Atomic Energy Agency, and Robert M. McKinney, the chairman of the U.S. Panel of Peaceful Uses of Atomic Energy.

Aerojet-General Nucleonics

One of the highlights of the exhibition was the display of an operating nuclear reactor at the stand of Aerojet-General Nucleonics, of San Ramon, California. The so-called "AGN-201" reactor, which is illustrated in Fig. 1, was operated at the low power of 100mW and performed demonstrations in reactor operation, the making of radioactive isotopes, the danger coefficient and pile oscillator testing of materials, and the performance of activation analysis.

The "AGN-201" unit was designed for use in education, research medical diagnosis, and industrial process control. It is especially intended for applications in which high thermal neutron flux is not necessary, but low cost, maximum safety, portability and high sensitivity are required. Its basic characteristics are shown in the following table :—

Characteristics of the "AGN-201" Reactor

Power, normal	100mW
Power, with special provisions	3W
Maximum thermal flux (100mW)	$4{\cdot}5\times10^{6}$n/cm²/sec
Critical mass	3,000 g of U (20% enriched)
Core size (cylinder)	10in dia., 9½in high
Moderator	11 kg polyethylene
Impregnation density (U-235)	50mg/cm²
Reflector (graphite)	20cm thick (1·70 gm/cm³)
Shield (lead) + (water with 3% HBO_3)	10cm thick (7500 lb) 55cm thick (8700 lb
Overall diameter	6ft 6in
Overall height	9ft
Overall weight of reactor unit	22,000 lb
Overall weight of reactor unit, with water shielding drained	13,300 lb
Temperature coefficient of reactivity	$-3{\cdot}6\times10^{-4}$/deg. Cent.

The reactor and control units are shown in Fig. 1 and are connected together by a cable. The shielding is designed to prevent the over-exposure of personnel even in the unlikely event of an accidental power surge. Additional safety features include power and reactivity monitors to operate a scram mechanism and a fuse that will cause the core to separate in case of a power surge.

In designing the "AGN-201" the objectives were to make the reactor as safe and foolproof as possible, to use a minimum of uranium no more than 20 per cent enriched, to provide an adequate exposure volume in the pile with a thermal-neutron flux as high as possible per unit of power, to make it as small, light and inexpensive as possible, to provide an effectively infinite life, and to provide a high analytical sensitivity for danger coefficient tests. Within certain constraints, the unit is a minimum-critical-mass reactor. Its critical mass is estimated as 600 grammes of U-235 in the form of 20 per cent enriched UO_2. It is contained in the form of a powder dispersed in a solid polyethylene moderator. No sacrifice in safety has been made to lower the amount of U-235 required. The theoretically smallest critical mass of U-235 is estimated to be under 300 grammes. Such a design would use a polyethylene moderator and a thick, high-density BeO reflector. The containers, control rods, &c., would increase the critical mass. A design of this type was considered, but it was discarded because of the health hazards and high cost associated with the handling of BeO. A thin high-density graphite moderator replaces the BeO.

Since the thermal neutron flux of any reactor is nearly proportional to power divided by critical mass, minimising the critical mass for safety reasons also provides the maximal neutron flux for any given power and fission product accumulation. The problem of size and weight of the "AGN-201" depends almost entirely on the shielding to prevent radiation over-exposure to personnel in a power surge. Thus more than enough is provided for normal operation of 100mW. The shield design was determined by estimates of the maximum conceivable accident. This was estimated as 2×10^{6} joules for a 2 per cent step change in reactivity. The maximal dose limit for personnel just outside the shield during such an accident had been chosen as 1 rem, the equivalent of three weeks at the "maximal permissible level" as established by the A.E.C. With the establishment of these parameters it was then possible to design a minimal-weight shield.

Sufficient evidence existed on the effects of ionising radiation on polyethylene to allow a fair estimate of core life. Experiments showed there should not be noticeable dimensional changes or foaming at doses of less than 1000 Mrep or 10^{11} ergs per gramme. Assuming that 10 per cent of the fission energy appears as ionising radiation in the polyethylene, the dose rate at 100mW is about 3 Mrep per year. Thus the core has an estimated minimal life of 300 years at a 100mW power level (twenty-four hours a day, seven days a week). The fuel burn-up is almost inconsequential, amounting to some 30 μgm per year. Thus there appears to be no fundamental reason why a very long life cannot be expected.

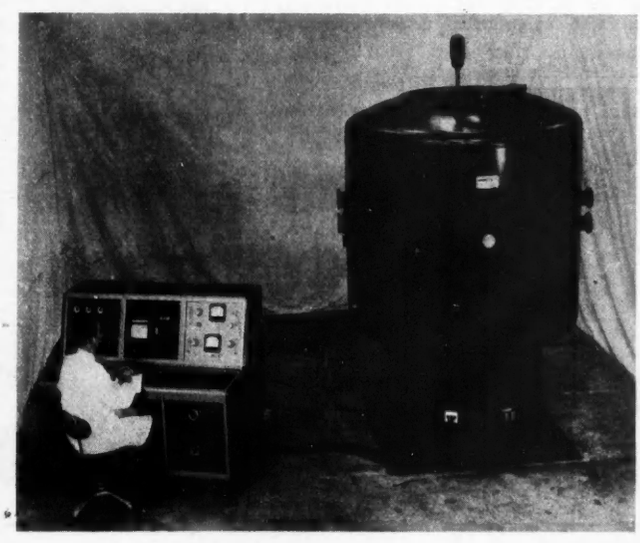


Fig. 1—"AGN-201" 100-milliwatt minimum-critical-mass reactor by Aerojet-General Nucleonics

To facilitate core construction and assembly, the core is made in nine sections of various thicknesses as shown in Fig. 2. The thinner sections allow varying the amount of U-235 in the core in small enough increments to obtain adequate control of the critical mass for assembly and experimental purposes. Each of the four bottom discs has three 5cm diameter holes and one 2·5cm hole. Two of these are for safety rods; one is for the coarse control rod, and the small one is for the fine control rod. A horizontal "glory hole," about 1in in diameter, passes through the centre of the reactor. The core discs are formed from a

mixture of polyethylene and UO_2 in the form of ten- to twenty-micron UO_2 particles. The total density of UO_2 is then 284 mg per cubic centimetre, yielding a weight ratio of 1 gramme of UO_2 to 3·16 grammes of polyethylene. A 10 millicurie Ra-Be source is situated in the graphite reflector to supply neutrons on start-up. With safety rods cocked and control rods all the way

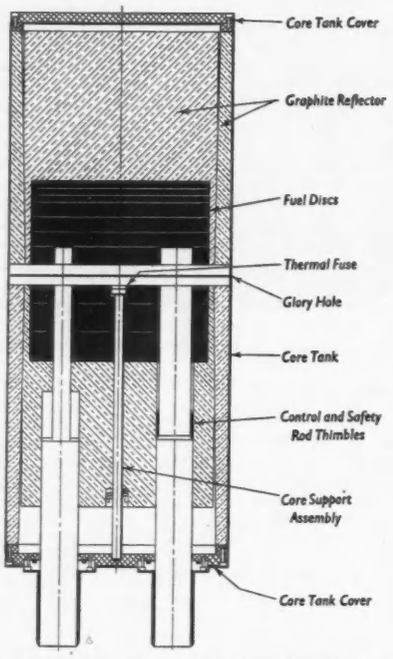


Fig. 2—Cross section of "AGN-201" reactor core, showing uranium discs, safety fuse and graphite reflector

out, the multiplication of the reactor is sufficient to generate 30μW of power and give indications on all instruments. Thus the reactor power can be safely varied by a factor of 3000 (0·030-100mW) by the use of the control rods.

The reflector consists of 20cm of high-density graphite on all sides of the core, as illustrated in Fig. 3. Appropriate holes are provided for the glory hole, safety and control rods, and access ports. Both the core and graphite reflector are surrounded by 10cm of lead shielding. The reflector weighs about 750 lb and the lead shield weighs about 6300 lb. A total of four access ports, together with the glory hole and a thermal column, are provided for experimental work. The four access ports pass completely through the reflector. The glory hole passes completely through the core. Under nomal operating conditions all ports are filled with appropriate plugs or stringers to match the surrounding materials.

As shown in Fig. 3, three concentric fluid-tight tanks surround the core. They are designated, respectively, the core tank, the reactor tank, and the water tank. The core tank has been designed to contain any fission gases given off by the core. Commercial alloyed aluminium is the structural material throughout. The tank has upper and lower sections, separated by an aluminium disc passing through the main cylinder in the same plane as the glory hole. This disc separates the core into two parts and is part of the safety fuse system. Detachable top and bottom cover plates, as well as control and safety rod thimbles, form an integral part of the tank. The lower section of the core tank contains half of the core material as well as a two-piece cylindrical section of graphite reflector. These pieces of core material and the inner piece of graphite reflector are supported by an aluminium rod projecting downward from a fuse link supported from the bottom cover plate. Ample space at the bottom of the cylinder is provided to ensure the free fall of the bottom half of the core reflector section when the fuse melts in any accidental power surge. This fall is further facilitated by a graphite-to-graphite taper joint that avoids binding. The upper section of the core tank is filled with six sections of core. A space for core expansion and gas accumulation is provided in the top of the tank.

The lead shielding, reflector and core are enclosed in and supported by a thick steel tank of 43·4cm radius. It has a removable top cover to permit access to the core tank. This tank acts as a secondary container for the core tank assembly and, with the glory hole and access ports closed, is completely fluid-tight. The water tank is the third and outermost of the fluid-tight containers. This main structural member is 6ft 6in in diameter and constructed of steel. Access can be gained to the top of the core assembly, even with water in the water tank, by removing the top cover plate and thermal column tank. The fast neutron water shield in the water tank consists of about 1000 gallons of water containing 250 lb of dissolved boric acid. The upper or "thermal column" tank serves as a shield when it is filled with water and lead or as a thermal column when it is filled with graphite. It is removable to allow taking out either the cover of the core tank or the core tank itself.

The "AGN-201" reactor has two safety rods and two control rods. The two safety rods and the coarse control rod are identical. The fine control rod is similar but has half the diameter of the others. Each rod contains 0–20 gramme of U-235 and operates so that reactivity is increased as the rod is inserted. The amount of reactivity each rod controls increases as the amount of active material contained increases. With the maximum of U-235 in the coarse rods each rod controls about 1·6 per cent reactivity. The fine control rod has been adjusted to control about 0·2 per cent reactivity. The active fuel in the control rod is enclosed in two aluminium containers. The outermost container provides the fluid seal with the core tank, and the innermost one seals the active fuel in the rod. By this design a double fluid-tight seal is maintained for the core and for the control and safety rods. The control and safety rods also serve another purpose. They provide a means of obtaining a fine adjustment of the uranium in the core, offering a convenient method of adding or removing small amounts of fuel. They are designed for use in critical experiments during start-up as well as for small adjustments in available reactivity under normal operating conditions.

The safety rods are in the safe or sub-critical position when they are pulled out. In this position the active fuel in the rod is just inside the lead shield. The rods are inserted one at a time by a drive mechanism requiring about one minute to travel the full 25cm stroke. The release mechanism is constructed so that if a scram signal is received at any time, the three large rods are driven to their outermost positions. The safety system is a "fail-safe" design. The scram signal opens the direct-pull holding magnets, allowing the rods to be accelerated outward by both gravity and compressed springs. The spring constant is such that the rods are initially accelerated with a force of $5g$, requiring a total withdrawal time of 140 milliseconds. The

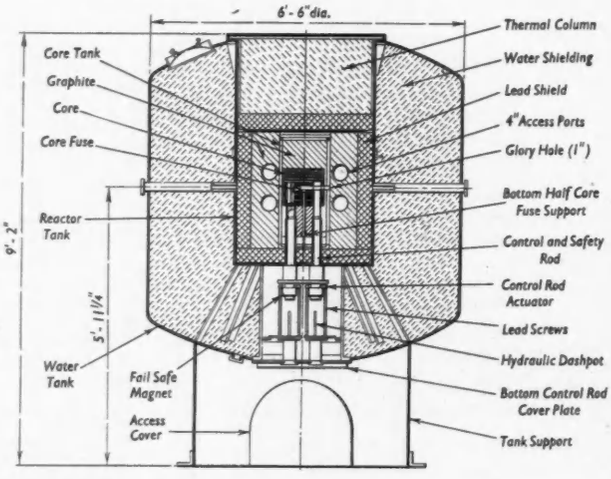


Fig. 3—Cross section of "AGN-201" reactor with core, reflector and shielding

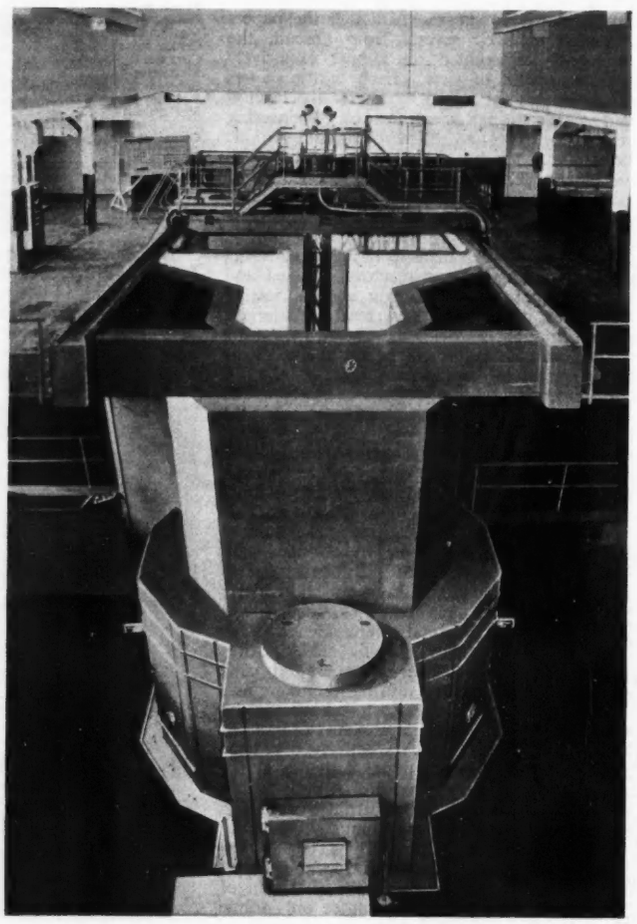


Fig. 4—Overall view of 1MW swimming pool research reactor installed at the Battelle Memorial Institute

reactivity change of both safety rods is 0·9 per cent during the first 50 milliseconds. The rods are decelerated by a hydraulic dashpot in the last 12·5cm of travel. Reversible d.c. motors drive both the coarse and fine control rods through lead-screw assemblies. The motors are controlled by switches at the control console. At maximum speed of travel the coarse rod causes a reactivity change of about 3×10^{-4}sec^{-1}. The positions of both control rods are indicated remotely at the control console. Interlocks prevent any control rod movement unless the safety rods are "cocked." The safety rods cannot be cocked until the control rods have reached their safe or starting positions.

The safety system of the reactor is designed to minimise the possibility of a nuclear runaway and, in the event of such an excursion, to protect the personnel from excessive radiation. The time constants of the scram system may not be such as to stop a fast excursion before the thermal expansion of the core would catch it. On the other hand, careful analysis shows that such self-limiting does prevent liberation of a dangerous amount of energy. The action of the core fuse and the safety rods then insures against a repetition of the same accident. The core fuse will heat faster than the core and melt at 100 deg. Cent. The fission products will be contained for the most part in the core. Since this is made of polyethylene cross-linked by radiation, it will not melt at the anticipated temperatures. If all the fission products created in the greatest conceivable accident were liberated in a room of 10^6 litre capacity, estimates indicate that the level of the most dangerous isotope, I-131, would be just barely at a dangerous level.

Battelle Memorial Institute

The display of the Battelle Memorial Institute, of Columbus, Ohio, emphasised the recently completed Nuclear Research Centre of the Institute, which is the first privately owned nuclear research facility in the United States and includes a 1MW swimming pool reactor. This unit became critical at the end of last year and is the largest pool reactor yet to be put into service in the United States. It was designed exclusively for research purposes. The Nuclear Research Centre was built in anticipation of the large expansion of nuclear research as a result of the U.S. Atomic Energy Act of 1954, which permitted private industry to enter upon the commercial development of the atom. The new reactor will be used in research on the chemistry of petroleum, sterilisation of pharmaceutical products, preservation of agricultural goods, and the improvement and development of numerous chemical, glass, plastic, ceramic and metallic products and processes. The Nuclear Research Centre was built entirely with the Institute's funds and is at liberty to contract with private industry for nuclear research without government security restrictions. In addition to a radiation laboratory, a reactor development and critical assembly laboratory and the research reactor, Battelle has other facilities for nuclear research. These include ore treatment and chemical engineering laboratories for the recovery of fissionable materials, a reactor materials laboratory and radio-chemical facilities.

The design of the Battelle research reactor, which is illustrated in Fig. 4, was conceived with the aim of creating a research tool having extreme versatility and flexibility because the kinds of research to be explored would be very numerous. The reactor design enables the technologists to perform experiments on all sorts of materials under many conditions with both neutrons and gamma-rays present and with either sort of radiation independent of the other. The experimental conditions can be arranged to include static irradiations of solids and liquids at room temperature and pressure, the irradiation of solid specimens at high temperatures and in a specified medium, and the irradiation of fluids in a dynamic system allowing for such conditions as heating and circulation. The Battelle research reactor, together with the hot-cell and critical assembly laboratories, is situated on a 400 acre site 15 miles west of the Institute's main laboratories at Columbus, Ohio. The reactor is housed in a three-storey building, 72ft wide by 100ft long. The two-section, water-filled pool, in which the reactor core is suspended, is approximately 20ft wide by 40ft long by 28ft deep.

The core, which is composed of fuel elements and boron control rods, takes up a space about 12in by 18in by 24in at the bottom of a support column which is suspended from the movable

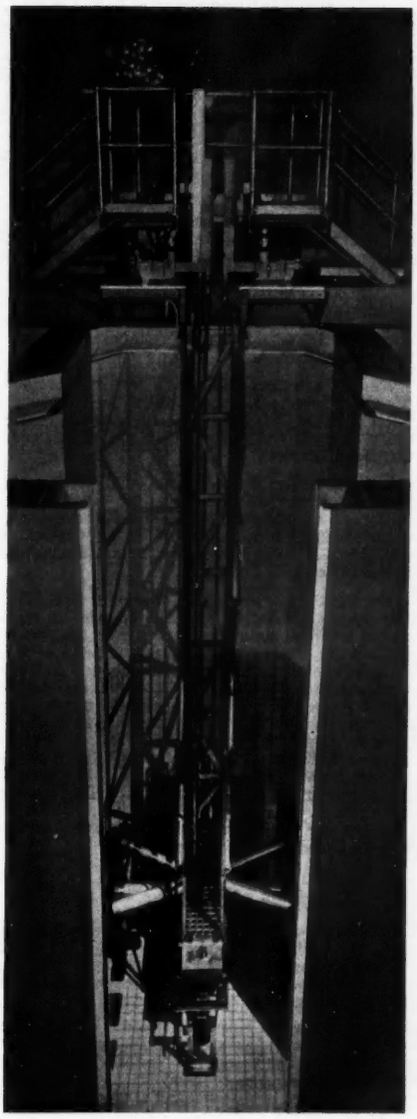


Fig. 5—Swimming pool reactor core at bottom of support column suspended from a movable bridge

control bridge, as shown in Fig. 5. The core operates at full power in either of two positions. One position is in the approximate centre of the pool, where bulk shielding and other large experiments may be performed. The other position is in a stall at one end of the pool, in front of the beam tubes and the graphite thermal column. A second movable bridge, with a support column extending downward to the level of the core face, is used for supporting instruments and specimens adjacent to the core. The cooling, shielding and control facilities are all designed for continuous operation at power up to 1MW.

Two 8in and four 6in diameter beam tubes extending from the outside vertical walls of the pool through to the face of the core are among the locations where specimens or experiments may be placed to utilise neutron or gamma radiation. At the 1MW level of power, the approximate radiation fluxes are 10^{13}n/cm^2/sec for fast and thermal neutrons and 5×10^{13} photons/cm^2/sec gamma flux. A second major location for irradiation is the graphite column that provides two 4ft openings with a thermal neutron flux of 5×10^8n/cm^2/sec. One of the special aspects of the reactor is that access to the thermal column is possible through a horizontal as well as a vertical face. For the fast irradiation of relatively small specimens, the reactor is equipped with a special "weasel tube." This will operate hydraulically to carry 2in diameter specimens to and from the core face with a minimum exposure time of about two seconds. Finally, for large experiments, the core may be moved to the centre of a 20ft by 20ft by 28ft pool area, where bulky apparatus may be brought close to its face.

The reactor fuel elements are composed of a uranium-aluminium alloy clad with "2S" aluminium. The uranium in the alloy is enriched to 90 per cent U-235. There are ten fuel plates in each element and a total of thirty-five elements containing, in all, 5·2 kg of U-235. The twenty-eight standard fuel elements contain 162 grammes of U-235 each, while the two partial elements, used for the fine adjustments in fuel loading, contain 81 grammes each. The five special elements in which the control rods operate contain about 100 grammes each. Depending on the core geometry, which is flexible, approximately 2·6 kg to 3·6 kg of U-235 are used to achieve criticality. At a power level of 1MW, roughly 1 gramme of U-235 is burned up each day.

The reactor was designed and constructed by the Atomic Division of the American Machine and Foundry Company, of New York, and the Atomic Energy Commission has issued Battelle a ten-year licence to operate the unit. The Institute has been active in nuclear research since 1939, when radioactive tracer studies were conducted. It has been conducting research and development on nuclear reactor fuel elements and materials continuously since 1942. Battelle has participated in such projects as the fabrication of the first 50 tons of uranium for the prototype of the Hanford piles and the preparation of fuel for the Materials Testing, Submarine, and Hanford reactors. Other fuel element research has been made for the Savannah River, General Electric, Pratt and Whitney, and Dow-Detroit Edison reactors. Battelle also conducted part of the research that led to the construction of the U.S.S. "Nautilus," the first atomic-powered submarine.

(To be continued)

Reactor Contract for Nuclear-Powered Merchant Ship

The U.S. Atomic Energy Commission has awarded to the Babcock and Wilcox Company, of New York, a 10,000,000-dollar contract for the design, development and fabrication of a nuclear reactor and the components of the propulsion plant for the first nuclear-powered American merchant ship. The ship is being built as a joint project of the Commission and the Maritime Administration of the U.S. Department of Commerce. Under the contract, Babcock and Wilcox will design, develop and fabricate a pressurised water reactor of an advanced design capable of a continuous output of 20,000 s.h.p. The reactor, which will have stainless-steel-clad uranium fuel elements enriched in U-235 to 2·9 per cent, will power both the ship's propulsion machinery and ship's auxiliaries, such as the electrical generation plants, heating system, and cargo handling equipment. The contract also covers the steam turbine, reduction gears, and electrical turbo-generators. The reactor containment vessel, biological shielding, certain reactor spare parts and other portions of the propulsion system, such as the propeller and shaft, will be contracted for at a later date.

The pressurised water reactor system was chosen to power the merchant ship because of the relatively advanced state of pressurised water reactor technology. This design offers the best prospect for early completion of the project, which is scheduled for early 1960. The reactor for this first American nuclear-powered ship will be unclassified and the reactor technology developed in the project will be available to American industry. It will also afford an opportunity to engineers and scientists of other nations to study the design and development of nuclear-powered ships.

Personal and Business

Appointments

MR. A. W. MORRISON has been appointed a director of Expandite, Ltd.

MR. KENNETH HORNE has been appointed a director of Saben, Hart and Partners, Ltd.

METAL INDUSTRIES, Ltd., has announced the appointment of Mr. Horace White as group public relations officer.

MR. T. A. NASH has been appointed manager of the plant and sales department of the British Central Electrical Company, Ltd.

MR. IAN MACGREGOR, M.I.Struct.E., has been appointed technical representative with the Coseley Engineering Company, Ltd.

MR. H. J. HYDE, A.M.I.Mech.E., A.R.Ae.S., has been appointed project engineer of the Hymatic Engineering Company, Ltd.

MR. F. BARRELL, M.I.Mech.E., M.I.E.E., has been appointed generation construction engineer, Central Electricity Authority headquarters.

BRITISH OXYGEN CHEMICALS, Ltd., has announced the appointment of Mr. A. J. Oxley as production manager at its works at Chester-le-Street.

THE INSTITUTION OF STRUCTURAL ENGINEERS has announced that Professor Sir Alfred Pugsley, M.I.C.E., has been elected president for the session 1957–58.

THE INSTITUTION OF PRODUCTION ENGINEERS has announced that The Right Hon. The Earl of Halsbury, F.R.I.C., has been elected president for the year 1957–58.

BRITISH RAILWAYS has announced the appointment of Mr. A. W. J. Dymond, M.I.C.E., M.I.Mech.E., as stores superintendent, Western Region, in succession to Mr. R. B. Hoff.

THE INTERNATIONAL HARVESTER COMPANY OF GREAT BRITAIN, Ltd., has announced that Mr. D. C. D'Arcy Biss, Mr. G. Gordon Davis and Mr. R. K. Rennie have been appointed directors.

THE STEEL COMPANY OF WALES, Ltd., has announced the appointment of Mr. A. J. K. Honeyman as superintendent of research for the steel division. Dr. C. S. Ball has been appointed chief metallurgist, steel division.

MR. E. G. GRINHAM has been retained as a consultant to the Dunlop Rubber Company, Ltd., and its subsidiary companies in connection with engineering products, including road and rail vehicle suspensions and brakes.

BLACK AND DECKER, Ltd., has announced the reconstitution of its board of directors. Sir Walter Puckey has been appointed a director; Mr. F. W. McCartney, assistant managing director, and Mr. W. O. Bell, production director.

THE BRITISH AND COMMONWEALTH SHIPPING COMPANY, Ltd., announces that Captain J. D. F. Elvish has been appointed group marine superintendent, and that it has appointed Captain C. Mitchell as marine superintendent of Clan Line Steamers, Ltd.

W. H. DORMAN AND CO., Ltd., has announced that Mr. Ian Macleod-Smith has been appointed sales manager. He will leave London on June 20 accompanied by Mr. J. W. Whimpenny, joint managing director and general manager, for Venezuela, to carry out market research and appoint agents.

HEPWORTH AND GRANDAGE, Ltd., has announced that Mr. G. Collin Hepworth has been appointed chairman. Mr. Jack L. Hepworth has been appointed a director of the parent company, Associated Engineering Holdings, Ltd., and Mr. Tom Booth, general manager of Hepworth and Grandage (Yeadon), Ltd., has been appointed a director of that company.

Business Announcements

G. AND J. WEIR, Ltd., states that it has acquired a controlling interest in the Canadian firm of Peacock Brothers, Ltd., Ville la Salle, P.Q.

LANCASHIRE DYNAMO HOLDINGS, Ltd., has announced the establishment of a company, Lancashire Dynamo Group Sales, Ltd., to take over the sales organisation in Great Britain. It will also co-ordinate the group's export sales.

TECALEMIT, Ltd., Plymouth, Devon, has announced that it has appointed Smith and Grace (Sales), Ltd., sole United Kingdom selling agents for its oil-firing equipment.

METAL AND PIPELINE ENDURANCE, Ltd., states that it has opened a branch office at 38–39, Exchange Buildings, Queen Street, Newcastle (telephone, Newcastle 2/9068).

MR. R. A. BARTLAM, A.M.I.E.E., system operation liaison engineer, East Midlands division of the Central Electricity Authority, is to retire at the end of June after fifty years' service.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., states that its Maidstone branch office now has an additional telephone number to the existing Maidstone 4001; it is Maidstone 51113/4.

JOHN MCLAREN, A.M.I.C.E., A.M.I.E.E., consulting engineer, states that his address has been changed to 13, Victoria Street, Westminster, London, S.W.1 (telephone, Abbey 4047).

GEMEC CHEMICALS, Ltd., states that it has moved from 120, Moorgate, London, E.C.2, to 103, Mount Street, London, W.1 (telephone, Legation 5361), and that it is now to be known as Union Carbide, Ltd., Chemicals Division.

TALBOT TOOL COMPANY, LTD.—On Wednesday, May 29, a luncheon was held at the Criterion Restaurant to celebrate the twenty-fifth anniversary of the coming into partnership of Mr. R. W. Griffiths and Mr. G. A. Bennett, which led later to the creation of the Talbot Tool Company, Ltd.

LOCOMOTIVE HOUSE.—The Locomotive and Allied Manufacturers' Association and constituent companies are now accommodated in new quarters at Locomotive House, Buckingham Gate, London. This new steel and reinforced concrete building accommodates the offices of the Association on the first floor, together with a conference room. The London offices of the Vulcan Foundry, Ltd., of the Hunslet Engine Company, Ltd., and of Robert Hudson, Ltd., are on the second floor; of the North British Locomotive Company, Ltd., on the third floor, and of Beyer Peacock and Co., Ltd., on the fourth floor. On the fifth floor, from which there opens a roof garden, there are a cinema, cocktail lounge, kitchen and dressing rooms.

Contracts

STENNERS OF TIVERTON, Ltd., Tiverton, Devon, has received an order for one of its "VQ" high-speed band mills from V/O Technopromimport of Moscow. It is hoped that the complete machine will be shipped to Russia towards the end of the year.

METROPOLITAN-CAMMELL CARRIAGE AND WAGON COMPANY, Ltd., has received an order for 100 refrigerator wagons from the New Zealand Government Railways. The company states that the total value of orders it has on hand at present for New Zealand is nearly £2,500,000.

W. T. HENLEY'S TELEGRAPH WORKS COMPANY, Ltd., has received from the Central Electricity Authority an order for the first cable on the new 50-cycle single-phase system of traction at 25kV, which the British Transport Commission has adopted for future electrification of British Railways. The power supply at this voltage will be taken from the C.E.A.'s 132kV grid at convenient substations, where it will feed into the overhead system of the railway. This contract covers the supply and installation of 4 miles of 25kV concentric paper-insulated oil-filled cable, together with a combined pilot and telephone cable for connecting the C.E.A.'s grid substation at Stockport with the British Railways' trackside substation at Heaton Norris Junction. The 25kV concentric cable is a new design of oil-filled cable, which has been developed by Henley's research laboratories especially for railway electrification work.

Miscellanea

CITY AND GUILDS INSTITUTE.—The City and Guilds of London Institute has secured a site at Portland Place, London, W.1, on which a new headquarters building is to be erected. It is hoped that the building will be ready for occupation early in 1959.

INDUSTRIAL LIGHTING.—A new film entitled "New Light on Industry," commissioned by the British Electrical Development Association was shown before an invited audience in London last week. The film emphasises the need for the "right light in the right place at all times," and illustrates these points with examples of good and bad lighting in the many factories, workshops and offices of organisations which helped in the making of this film. Increased productivity, fewer accidents and less industrial fatigue, are some of the benefits to which the film draws attention by its illustrations of the uses of correct lighting. The film runs for thirty minutes and is available in 16mm and 35mm sizes.

EXPORT PROCEDURE.—The Engineering Industries Association has published a fifth edition of its *Handbook of Export Procedure*. The information contained in it provides an up-to-date guide to the whole sequence of export trading procedure, and a useful glossary of export terms is also included. The booklet is available (price 5s. 6d.) from the Engineering Industries Association, 9, Seymour Street, London, W.1.

COMPUTER APPRECIATION COURSE.—A three-day computer appreciation course is being arranged by Ferranti, Ltd., to take place on July 3, 4 and 5 at 21, Portland Place, London, W.1. This course, which is intended for directors and senior executives, will deal with the uses of computers in scientific management, and will not cover specifically the application of computers to routine accounting work. Full details and application forms can be obtained from Ferranti, Ltd., at the address given above.

TECHNICAL AUTHORSHIP.—Last year, the City and Guilds of London Institute published the regulations and syllabuses for examinations in technical illustration. Courses for these examinations are now being provided at twenty-three colleges. The Institute says that it has now been asked to provide a scheme in the complementary field of technical authorship. A committee is being set up to explore the problem of the training and qualification of technical authors, and, if thought desirable and practicable, to draft a scheme of syllabuses and examinations.

THE "TURNKEY" CONTRACT.—We have received a copy of an illustrated brochure prepared by Taylor Woodrow, Ltd., which is in effect a statement for shareholders, describing the company's activities in 1956, and also the activities of its various subsidiaries. The year was one of continued expansion, it is pointed out, and the profit for the year, after allowing for expenses, depreciation and taxation, was £335,379. In his review of the year's work, Mr. Taylor, the company's chairman, pointed out that he considered that the "turnkey" or negotiated contract, was advantageous. If the firm was consulted in this manner, he said, it was able to plan, design and erect a complete project. By that method it was able to save time and effect substantial economies.

STAINLESS STEEL SOLDERING.—Particulars have been received of a new solder paint for speedy hot tinning of stainless steel which has been developed by Perdeck Solder Products, Ltd., Waltham Abbey, Essex. This product is known as "Epatam 3311," Code PLF.73/11, and is stated to effect the tinning and soldering of stainless steel as simply and easily as when working on copper or bright mild steel. The makers say that the material's high degreasing and penetration properties enable it to tin through iron welding scales, rust and grease, in addition to its major use on stainless steel. When used this solder paint is simply painted straight on to the steel and heated by any convenient method to normal soldering temperature. If used on brass or copper, it may be slightly diluted with water for greater economy.

MAUDSLAY SOCIETY.—More than fifty members and guests attended the annual luncheon of the Maudslay Society in London last Friday. Responding to the toast of "The Guests," which was proposed by Mr. J. Foster Petree, Mr. Bryan Donkin spoke of the close association between the society and the Junior Institution of Engineers, which had given much assistance in selecting applicants for the Maudslay scholarships. The next speaker, Sir Theodore Pritchett, dealt at some length with the activities of the successors to the business founded by Henry Maudslay, and mentioned the valuable contribution the society was making in its assistance to young engineers with the scholarship scheme. Two Maudslay scholars, Messrs. C. R. Evans and M. J. C. Swanson, were presented with certificates by Mr. W. W. S. Robertson, the president of the Society, who described some of the work and achievements of Maudslay. At present, Mr. Robertson said, the investments of the society resulted in an annual income of just over £430, which in the current year had been used to award four sums of £50 and two of £100 to young men chosen from some twenty-eight applicants.

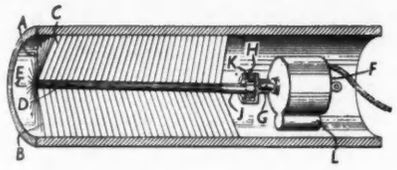
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane W.C.2, 3s. 6d. each.

TUBES, PIPES AND CONDUITS

775,106. May 24, 1954.—APPARATUS FOR TRAVELLING THROUGH PIPES AND CONDUITS FOR THREADING AND CLEANING, Constantine Panayotis Xenis, 243, Forest Road, Douglaston, Long Island, New York, U.S.A.

The invention relates to apparatus for travelling through pipes, conduits and the like for threading and/or cleaning. Referring to the drawing the apparatus is shown in position for travelling through a conduit *A*, the passage of which is of substantially circular cross section. A brush is shown at *B* of a cross sectional shape substantially corresponding to that of the passage of the conduit through which it is to travel. It consists of a number of bristles, as at *C*, which are secured to a core member *D*. The bristles extend generally radially from the core member and hold it substantially centrally in the conduit. Furthermore, the bristles, although extending generally radially from the core member, are



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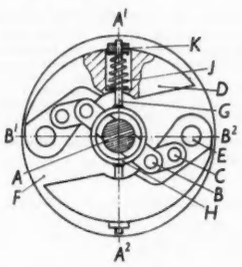
tilted relative thereto in a common direction, backward with respect to the direction of motion of the apparatus indicated by the arrow *E*. When the apparatus propels itself through the conduit a vibratory motion is imparted to the brush in a direction substantially at right angles to the longitudinal axis of the brush or the longitudinal axis of the passage of the conduit. In the form shown, such motion is effected by moving the core member of the brush in such a manner that it generates a generally conical surface of revolution. For this purpose a motor *F* is employed having a shaft *G*, which, through the intermediary of an eccentric *H* is connected to the rear extremity *J* of the core member *D*. A suitable anti-friction bearing, as at *K*, is employed in the eccentric to prevent the transmission of a torque to the core member, which would otherwise cause it to rotate about its longitudinal axis. Suitable means are provided for preventing the housing or frame of the motor from rotating—for example, a counterweight *L* secured to the housing to lower the centre of gravity of the motor below the level of its connection with the core member *D* so that pendulum forces restrain the motor from rotating. Alternative arrangements for both circular and rectangular conduits are also shown in the specification.—*May* 22, 1957.

POWER TRANSMISSION

775,214. February 9, 1955.—AUTOMATICALLY ADVANCED COUPLING DEVICES FOR ROTATING SHAFTS, Louis Grisel, 17, Bis, Quai Voltaire, Paris, France, and Henri Trousson, 28, rue Saussure, Paris, France.

The invention relates to a coupling device between a driving shaft and a driven shaft, comprising means whereby the angular relationship between these two shafts varies automatically within predetermined limits, as a function of the speed of rotation of the shafts. Such a device may be used particularly for automatically regulating the advance of the injection



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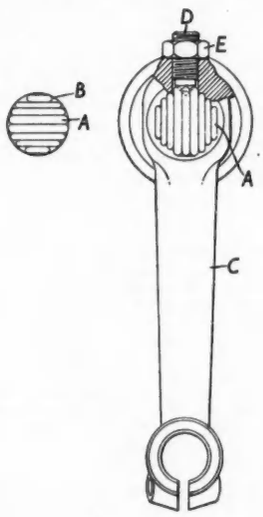
pumps of diesel engines. As will be seen from the drawing, *A* is the driving shaft, carrying on its hub a cross member terminating at its extremities in shafts *B* on which are articulated links which are also articulated on shafts *C* carried by the weights *D*. These weights can pivot about shafts *E* carried by a plate *F* on the driven shaft. The return is effected by means of two symmetrical rods *G* rigidly connected to a ring *H* floating freely about the shaft *A*. These rods *G* traverse the weights, and round each of them is mounted a spring *J* which abuts against the weight, and which is compressed at its other end by the regulating screw *K*. The holes in the weights *D* for the passage of the rods *F* are orientated along a radius A^1 and A^2, starting from the axis of the device and forming a right angle with a line B^1 and B^2 passing through the axis and the pivotal point of the weight when the weight is half way along its path. The ring *H*, which is arranged round the hub of the device. may be replaced by a simple rod, comprising an elbow, maintaining it at a certain distance from the hub. Such a device procures the maximum efficiency while being very compact and occupying the minimum amount of room. With a view to reinforcing the action of the device, provision is also made for being able to superimpose several such assemblies as that described, with the same orientation or with different orientations.—*May* 22, 1957.

775,249. August 8, 1955.—TORSION BARS, Volkswagenwerk G.m.b.H., Niedersachsen, Wolfsburg, Germany.

The invention concerns torsion bars, in which a torsion bar assembly comprises a series of parallel, superimposed spring leaves arranged chordally or substantially chordally with respect to a circumscribing circle in such a manner as to enable said assembly



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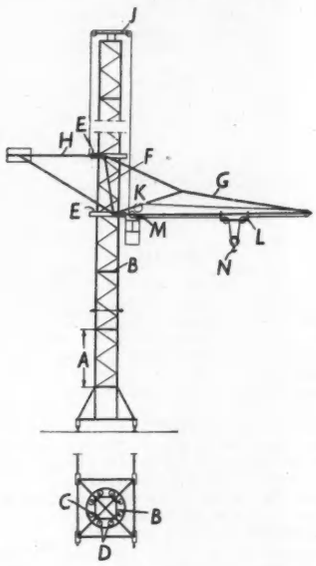
to be received within a bush of circular or substantially circular cross section. The left-hand view is an end elevation of a group of spring bars constructed in accordance with the invention, and the right-hand view is an end elevation, partly in section, of a torsion bar and supporting arm assembly constructed in accordance with the invention. The torsion bar assembly shown to the left consists of eight single bars *A* of different width and thickness from one another, and presenting a total cross section which almost completely occupies the circumscribed circle *B*. In the embodiment shown to the right, a supporting arm *C* is formed at one end with an internal, toothed bore of substantially circular section, in which is received a torsion bar assembly comprising nine bars *A* varying both in thickness and in width. The three centre bars are of identical dimensions, but the three bars on either side thereof will be observed to be of successively decreased width and thickness. The dimensions of the assembly as a whole are, of course, chosen to enable the assembly to be admitted within the toothed bore. The bars *A* are retained in the supporting arm *C*, against axial displacement, by means of a screw *D* and locknut *E*. —*May* 22, 1957.

CRANES AND LIFTING APPLIANCES

775,128. September 21, 1954.—TOWER CRANES, M. Tichauer Societe a Responsibilite Limitee, 44, rue Moliere, Lyons, Rhone, France.

The invention relates to tower cranes, its object being to provide an improved tower crane. From the drawing it will be seen that the tower crane comprises a fixed mast of constant square section, constituted by a number of standard elements of height *A*. These elements each comprise, at any desired level—for example, at the ends—a braced frame *B*, provided at each corner with two pierced stay-plates or any other arrangement permitting of fixing a roller or a pivoted member *C* (Fig. 2) carrying two rollers *D*. The pivoted members *C* pivot about vertical axes. Upon the mast there is mounted in sliding fashion a travelling assembly comprising two collars *E* of internal diameter greater than the circle enclosing the square section of the mast, so that they may serve as surfaces for rolling upon the rollers *D* carried by the frames *B*. These two collars are placed at a distance from one another corresponding to the constant spacing of the frames *B*, in this case the height *A*. They are joined by two uprights *F* at the ends of which there are attached the base and end of tie rods of the boom *G* and the counter-boom *H*. An arm *J* mounted at its middle on a pivot, supported by a thrust bearing against the upper face of the top



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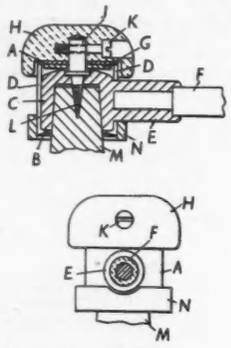
element of the tower, and of suitable length, slightly greater than the diameter of the collars *E*, supports a pulley at each of its two ends. The hoisting cable commencing from the main hoisting winch *K* mounted on the base of the boom *G*, passes over the pulley at the end of the boom, then into the trolley *L* and at the base of the boom successively into a releasable cable clamp *M* and a return pulley, then rising to the top of the mast in order to pass over the pulleys of the arm *J* and to be secured to the counter-boom as shown. In order to bring the assembly of boom *G* and counter-boom *H* from the bottom of the mast, to the optimum working height, the hook *N* is brought against the trolley *L*, the removable cable clamp *M* being released. By winding up, the winch raises the travelling assembly ; by unwinding as for lowering it causes the travelling assembly to descend again. At the desired working height, the assembly being brought to the position where the two collars *E* are in line with the rollers *D* of two frames provided with rollers, the cable clamp *M* is locked, so that one end of the part of the cable part used for lifting the load is fixed. The lateral forces due to hoisting are transmitted to the two collars rotating on the rollers *D*, which transmit the forces to the mast through the frames *B*. The vertical forces due to the weight of the travelling assembly in addition to the load, are transmitted to the pivot upon which the arm *J* rotates. Modifications can be introduced in the form of embodiment described and represented, without departing from the invention.—*May* 22, 1957.

ELECTRICAL ENGINEERING

775,146. February 8, 1955.—ELECTRIC STORAGE BATTERY TERMINALS, Joseph Lucas (Industries), Ltd., Great King Street, Birmingham, 19. (*Inventors : Robert Hesketh Purden and Eric Bernard Parkes.*)

The invention relates to electric storage battery terminals comprising a metal plug of tapered form extending from a pole of the battery, and a complementary metal socket fitting the plug tightly, to which a cable can be attached. Referring to the drawing, the sleeve *A* is of cylindrical form and is preferably made from a flexible plastic material, such as polythene. At its inner end the sleeve has formed on it a narrow inwardly directed annular lip *B* which can engage the lower edge of the terminal socket *C*. Also it has formed on it at least a pair of longitudinal slots *D* extending from its inner end sufficiently to enable the sleeve to be expanded when being placed

in position on the socket. Further, the sleeve has formed in it a side gap which enables it to pass over a laterally extending hollow lug *E* on the socket to which the cable *F* is attached. Within the outer end of the socket is secured a metal reinforcing disc *G* having a central hole, and on the end of the sleeve is mounted a rotatable cap *H* adapted to provide a convenient hand grip. The cap may be made from a mouldable plastic material, or it may be made from metal. The cap and sleeve are secured together by an axial stem *J* which, at one end, is embedded in the cap and is secured to it by a peg *K*. This stem extends



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freely through the disc in the sleeve, and the part which lies within the sleeve has formed on it a screw thread *L* which can be engaged with a screw threaded hole on the axis of the terminal plug *M*. After the sleeve has been placed on the socket, a tightly fitting ring *N* is placed over its inner end to hold the lip of the sleeve in secure engagement with the inner end of the socket. The arrangement is such that, after the attachment has been placed on the socket, the latter can be engaged with the plug by rotation of the cap and screw, the socket being thereby pressed into tight contact with the plug. To detach the socket from the plug, the cap is rotated in the opposite direction and the interaction of the screw and plug causes the sleeve, by the force exerted through its lip on the lower end of the socket, to lift the latter off the plug.—May 22, 1957.

Technical Reports

Eighth Annual Report of O.E.E.C. Vol. I: Europe To-day; Vol. II: Europe in 1960. Paris: The Organisation for European Economic Co-operation, 2, rue André-Pascal, Paris (16e). Price 7s. each volume. Obtainable from H.M. Stationery Office, P.O. Box 569, London, S.E.1.—The *Eighth Annual Report of O.E.E.C.* was published in two parts on April 12 and 24. The first volume is concerned with a review of economic conditions and problems up to the end of 1956 and contains a chapter on the economic impact of the Suez crisis. Vol. II presents a quantitative appreciation of future developments, which shows the economic possibilities open to Europe, and describes the problems which have to be tackled if continued expansion is to be achieved.

A.E.G. Hilfsbuch für Elektrische Licht-und Kraftanlagen. Issued by Allgemeine Elektricitäts-Gesellschaft, Berlin-Grunewald, Essen: Verlag W. Girardet. Price DM.19,80.—The present seventh edition of this well-known handbook comprises sections concerned with electricity generation, transformation, switching, circuit protection, measurements, transmission and consumption, including as main fields electric motors, lighting and heating. The material has been brought up-to-date from 1952, when the previous edition appeared, and a section on process control has been added.

Saunders-Roe "Princess" Flying Boat G-ALUN Air and Water Performance Tests. A.R.C. Current Paper No. 279. H.M. Stationery Office. Price 5s. 6d. —The basic air drag characteristics of the aircraft are good, being considerably better than has been achieved on previous British flying boats. There are points on the aircraft where elimination of air leaks (e.g. the wing tip to float junction and control surfaces) and surface roughness (particularly on the outer wings) could lead to an improvement in these already good drag characteristics.

During take-off, with the derated engines, the minimum longitudinal acceleration at the maximum drag (hump) speed, in a sea of up to 1ft, is 2·04ft/sec² (0·063 *g*) at an aircraft weight of 295,000 lb. Employing the corresponding mean engine output derived from the single engine torquemeters, the propeller thrust calculated from the manufacturers' performance curves indicates an approximate total resistance of 0·183*W*. At 295,000 lb, commencing from a taxi-ing speed of 15 knots, the distance to attain an unstick speed of 100 knots is 4750ft, with a fixed elevator setting of −9 deg.

Launches and Trial Trips

ZAPHON, oil tanker; built at the Wallsend yard of Swan, Hunter and Wigham Richardson, Ltd., for Shell Tankers, Ltd.; length between perpendiculars 675ft, breadth moulded 89ft, depth moulded 49ft, load draught 36ft 2¼in, deadweight 38,390 tons, service speed 16½ knots; thirty-three oil cargo compartments, one main cargo pump room, three 1056 tons per hour vertical centrifugal turbine-driven cargo pumps and three vertical duplex steam-driven stripping pumps; steam deck machinery; two 600kW, 480V, turbine-driven alternators, one 150kW diesel-driven alternator; one set of double-reduction geared turbines, built by The Wallsend Slipway and Engineering Company, Ltd., 16,500 s.h.p. at 108 propeller r.p.m., five-bladed propeller; two Babcock and Wilcox integral furnace boilers supply steam at 600 lb per square inch and 850 deg. Fah.—Trial, April 24.

VIVIPARA, oil tanker; built by the Netherlands Dry Dock and Shipbuilding Company, Amsterdam, for N.V. Petroleum Maatschappij "La Corona"; length between perpendiculars 634ft 10in, breadth 84ft 3in, depth 46ft 3in, deadweight 32,150 tons, speed 16½ knots; four 1000 tons per hour cargo pumps; two 550kW turbine-driven alternators, one 150kW diesel-driven alternator; one set of N.D.S.M. h.p. and l.p. double-reduction geared turbines, 13,500 service s.h.p., 15,000 maximum s.h.p., two Babcock and Wilcox boilers generate steam at 600 lb per square inch and 850 deg. Fah.—Launch, April 27.

LONDON TRADITION, oil tanker; built by the Furness Shipbuilding Company, Ltd., for London and Overseas Freighters, Ltd.; length between perpendiculars 560ft, breadth moulded 80ft, depth moulded 42ft 3in, deadweight 24,800 tons on 32ft 4in summer draught; twenty-seven cargo oil compartments, one main cargo pump room, three 1000 tons per hour turbine-driven centrifugal cargo pumps, three 150 tons per hour vertical duplex stripping pumps; two 325kW turbine-driven generators, one 100kW diesel-driven generator; one set of Richardsons Westgarth double-reduction geared turbines, 7300 service s.h.p. at 100 propeller r.p.m., 8200 maximum s.h.p. at 104 propeller r.p.m., steam supplied at 450 lb per square inch and 750 deg. Fah. by two Foster Wheeler "D" water-tube boilers.—Launch, April 29.

CLAN MALCOLM, cargo liner; built by the Greenock Dockyard Company, Ltd., for the Clan Line Steamers, Ltd.; length between perpendiculars 465ft, breadth moulded 65ft 6in, depth moulded 39ft 7¼in, deadweight 9760 tons on 27ft 3in mean draught, service speed 16½ knots; twelve passengers; five holds, one 80-ton, two 40-ton, two 15-ton, four 7-ton, ten 5-ton and two 3-ton derricks, electric winches; three 220kW diesel-driven generators; Wallsend-Doxford opposed-piston, diaphragm oil engine, six cylinders, 750mm diameter by 2500mm combined stroke, arranged to burn heavy fuel, 7500 b.h.p. at 103 r.p.m.—Launch, April 29.

SILVERFELL, cargo ship; built by Joseph L. Thompson and Sons, Ltd., for the Silver Line, Ltd.; length between perpendiculars 421ft, breadth moulded 59ft 6in, depth moulded 38ft 2in, deadweight 11,600 tons on 28ft 10in summer draught; service speed 13¾ knots; five holds; Doxford oil engine, four cylinders, 670mm diameter by 2320mm combined stroke.—Launch, April 30.

PICARDY, cargo liner; built at Belfast by Harland and Wolff, Ltd., for Royal Mail Lines, Ltd.; length between perpendiculars 415ft, breadth moulded 58ft 6in, depth moulded to shelter deck 38ft 4in; five holds, fourteen derricks and one 30-ton derrick; three 150kW diesel-driven generators; Harland and Wolff two-stroke, single-acting, opposed-piston oil engine, six cylinders, 620mm diameter by 1870mm combined stroke.—Launch, April 30.

Catalogues and Brochures

J. GOULDER AND SONS, Ltd., Kirkheaton, Huddersfield.—Brochure entitled "Goulder Rolling Gear Testers," describing rolling gear testers.

SPIRAX-SARCO, Ltd., Charlton House, Cheltenham.—A folder of pamphlets giving quick reference to the equipment manufactured and sold by this company.

MILLARS' MACHINERY COMPANY, Ltd., Pinners Hall, Great Winchester Street, London, E.C.2.—Brochure entitled "The Miracle of Vacuum Concrete," detailing the advantages of vacuum concrete.

NEWMAN, HENDER AND CO., Ltd., Woodchester, Stroud, Glos.—Catalogue No. 101P, entitled "Valves and Fittings for all Requirements of the Petroleum Industry," describing and illustrating equipment for use in the refinery and petroleum industry.

HADFIELDS, Ltd., East Hecla Works, Sheffield.—Brochure No. 482, entitled "Single Toggle Breakers and Granulators," the breakers are made in five sizes for the production of the coarser grades of stone and the outputs, based on crushing hard limestone to 2½in ring, range from 3 to 15 tons per hour. The granulators are intended for the further reduction to sizes suitable for top dressing, and the outputs here, based on hard limestone to approximately ¾in cube, range from 3 to 10 tons per hour.

SHORROCK SUPERCHARGERS, Ltd., Empress Works, Walsall Road, Willenhall, Staffs.—Leaflet illustrating and describing gas oil burners, models "S.D.2" and "S.D.3," these burners are claimed to operate on a wide range of fuels—diesel oil, paraffin, T.V.O., C.T.F.50, filtered waste engine sump oil, and, with slight modifications, waste transformer oil—due to the fact that oil pumps and small jet orifices are omitted from the burner, and the fuel is first carburetted, and, further, it is passed through two stages of atomisation.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, June 7, to Sat., June 15.—OXFORD, READING AND DISTRICTS BRANCH: Visit to Austria.

To-day, June 7.—LIVERPOOL BRANCH: Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, Annual General Meeting, 6.30 p.m. ★ S. LONDON BRANCH: Half Moon Hotel, Broad Green, Croydon, Annual General Meeting, 7.15 p.m.

Mon., June 10.—CENTRAL LONDON BRANCH: White Hall Hotel, Bloomsbury Square, London, W.C.1, Annual General Meeting, 6.30 p.m.

Wed., June 12.—BIRMINGHAM BRANCH: Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, Annual General Meeting, 6.30 p.m. ★ BRADFORD BRANCH: Midland Hotel, Bradford, General Meeting, 7.30 p.m.

Thurs., June 13.—PORTSMOUTH BRANCH: Royal Beach Hotel, Southsea, Annual General Meeting, 7.15 p.m. ★ S.W. LONDON BRANCH: Prince of Wales Hotel, Hartfield Road, Wimbledon, London, S.W.19, Annual General Meeting, 7.15 p.m.

Fri., June 14.—BRISTOL AND W. OF ENGLAND BRANCH: Grand Hotel, Bristol, Annual General Meeting, 7.45 p.m. ★ STOKE AND CREWE BRANCH: Royal Hotel, Crewe, Annual General Meeting, 7.30 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Wed., June 12.—LONDON REGION: St. Ermin's Hotel, Westminster, London, S.W.1, "Coal: Some Forecasts," R. J. Moffat, 10.30 a.m.

Wed., June 19.—WELSH REGION: Park Hotel and Whitehall Rooms, Cardiff, "The Reduction of Smoke and the Efficient Control of Combustion by Instrumentation," W. R. L. Kent, 10.30 a.m.; "The Effect of Coal Characteristics on the Operation of Mechanical Stokers," D. C. Gunn, 2.30 p.m.

INCORPORATED PLANT ENGINEERS

Thurs., June 20.—MERSEYSIDE AND N. WALES BRANCH: Stafford Hotel, City Road, Chester, "New Developments in Chemical Engineering Materials," E. Warde, 7.15 p.m.

INSTITUTE OF NAVIGATION

To-day, June 7.—JOINT MEETING WITH INSTITUTE FRANCAIS DE NAVIGATION AND AUSSCHUSS FUR FUNKORTUNG: Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "The Avoidance of Collision by Airborne and Shipborne Means."

Fri., June 21.—LONDON MEETING: Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "The Accuracy of Astronomical Observations at Sea," D. H. Sadler, 5.15 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Wed., June 12.—LONDON BRANCH: Visit to the School of Gas Turbine Technology, Farnborough, Hants, 11.15 a.m.

Thurs., June 20.—LONDON BRANCH: Visit to the Sugar Refinery of Tate and Lyle, Ltd., Silvertown, London, E.16, 2 p.m. ★ YORKSHIRE CENTRE: Visit to Triplex (Northern), Ltd., St. Helens, Lancs, 11.45 a.m.

Wed., June 26.—E. MIDLANDS CENTRE: Day Visit to Birmingham and Midlands Omnibus Company, Ltd., Birmingham.

INSTITUTION OF CIVIL ENGINEERS

Wed., June 19.—Great George Street, Westminster, London, S.W.1, "Conversazione," 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Fri., June 14.—MEASUREMENT AND CONTROL SECTION: Visit to The British Thomson-Houston Company, Ltd., Taylor, Taylor and Hobson, Ltd., Charnford, Leicester, 8.15 a.m.

Fri., June 28.—EDUCATION DISCUSSION CIRCLE: Northampton Polytechnic, St. John Street, London, E.C.1, Exhibition of Apparatus for Teaching Electrical Engineering, 6–8.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Tues. to Thurs., June 25 to 27.—39, Elmbank Crescent, Glasgow, C.2, Centenary Celebrations.

INSTITUTION OF MECHANICAL ENGINEERS

Sat., June 15.—LONDON GRADUATES AND STUDENTS SECTION: 1, Birdcage Walk, Westminster, London, S.W.1, Joint Meeting with the Southern Branch Graduates Section for the "Graduates Summer Meeting," 9.30 a.m.

INSTITUTION OF MINING AND METALLURGY

Thurs., June 20.—GENERAL MEETING: Geological Society of London, Burlington House, Piccadilly, London, W.1, Discussions on "Mechaniams of Collector Adsorption and Dynamic Attachment of Particles to Air Bubbles as Derived from Surface-Chemical Studies," J. Leja; "Flotation of Soluble Salts," J. Rogers; "The Assessment of Flotation Results," J. C. Nixon and D. N. Moir, 5 p.m.

MANCHESTER GEOLOGICAL AND MINING SOCIETY

To-day, June 7.—SUMMER MEETING: Visit to Altham Coke Works, 10 a.m.

ROYAL SOCIETY OF HEALTH

Wed., June 12.—LONDON SESSIONAL MEETING: 90, Buckingham Palace Road, London, S.W.1, "The Effects of Radiation on the Individual," F. G. Spear, 2.30 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Tues., June 11.—CHEMICAL ENGINEERING GROUP: 14, Belgrave Square, London, S.W.1, "Granulation," W. C. Peck, 5.30 p.m.

WOMEN'S ENGINEERING SOCIETY

Wed., June 26.—Hope House, 45, Great Peter Street, Westminster, London, S.W.1, Annual General Meeting, 7 p.m.